UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON D.C., 20460

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Date: October 26, 2020

MEMORANDUM

SUBJECT: **Dicamba DGA and BAPMA salts** – 2020 Ecological Assessment of Dicamba Use on Dicamba-Tolerant (DT) Cotton and Soybean Including Effects Determinations for Federally Listed Threatened and Endangered Species

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The Environmental Fate and Effects Division (EFED) has completed a Section 3 new use ecological risk assessment, including effects determinations for Federally listed threatened and endangered species, for over-the-top product registrations for use on dicamba-tolerant soybeans and dicamba-tolerant cotton.

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OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

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2020 Ecological Assessment of Dicamba Use on Dicamba-Tolerant (DT) Cotton and Soybean Including Effects Determinations for Federally Listed Threatened and Endangered Species

October 26, 2020

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Section 3 New Product and Product Amendment Risk Assessment

EXECUTIVE SUMMARY

This document describes the EPA's assessment of the potential environmental risks to non-listed taxa and federally listed threatened or endangered species (listed species) from the use of dicamba on dicamba-tolerant soybean and cotton crops. This supports EPA's evaluation of applications for products containing the herbicide dicamba for pre- and post-emergent (in-crop) use on dicamba-tolerant soybeans and cotton.[1]

The dicamba registration actions considered in this ecological risk assessment for pre- and post-emergent use are the following restricted use products:
- Tavium (A21472) Plus VaporGrip® Technology [diglycolamine (DGA) salt of dicamba 17.7% a.i. and S-metolachlor 24.0% a.i.], EPA Reg. No. 100-1623,
- Engenia® Herbicide [N,N-Bis-(3-aminopropyl)methylamine salt of 3,6-dichloro-o-anisic acid (BAPMA) 60.8% a.i.], EPA Reg. No. 7969-UTE, and
- XtendiMax® With VaporGrip® Technology, Alternative brand name: M1768 Herbicide [diglycolamine (DGA) salt of dicamba (3,6-dichloro-o-anisic acid) 42.80% a.i.], EPA Reg. No. 264-RERN.

The labels that EPA assessed allow for 2 applications of 0.5 lbs acid equivalent (a.e.) dicamba per acre (0.5 lb a.e./acre) as a pre-plant "burndown," pre-plant, at-plant, or preemergence. The labels for XtendiMax and Engenia also allow for an additional 2 over-the-top post-emergence applications (in-crop) at 0.5 lbs a.e./A, whereas the Tavium label is restricted to only a single over-the-top post emergence application of 0.5 lbs a.e./A. The maximum annual application, from the labeled products and inclusive of other applied dicamba products, is not to exceed an annual maximum of 2.0 lb a.e./acre.

The products are for use on dicamba-tolerant soybean and cotton only in the following states:

Alabama, Arizona, Arkansas, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin. There are specific counties, 287 out of a total of 2671 or 13% of the total soybean acres and 15% of the total cotton acres include listed species for which stricter control measures are required on the labeling. See Section 2.2 for complete details.

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[1] Applications include an amendment to extend the expiration date for A21472 Plus VaporGrip Technology (Alternate Brand Name: Tavium Plus VaporGrip® Technology), and for new registrations for Engenia Herbicide and XtendiMax with Vaporgrip Technology.

Each of the product labels include the following application requirements to address spray drift, volatile emissions or runoff from the application of the products:

- Spray drift
  - Application equipment must use spray nozzles and pressure settings from an approved equipment list maintained at www.engeniatankmix.com, www.TaviumTankMix.com, or www.XtendiMaxapplicationrequirements.com, product dependent.
  - XtendiMax® With VaporGrip® Technology must be mixed in solution with an approved drift reduction adjuvant as specified on the approved list maintained at www.XtendiMaxapplicationrequirements.com.
  - Tavium requires that an approved drift reduction agent (DRA) must also be included in the spray solution, unless otherwise indicated on www.TaviumTankMix.com.
  - Use only approved tank-mix partners from a list maintained at www.engeniatankmix.com, www.TaviumTankMix.com, or www.XtendiMaxapplicationrequirements.com , product dependent.
  - Application is only allowed by ground spray equipment and with a maximum spray boom height of 24 inches above pest or crop canopy
  - Application can only occur when boom-height wind speed is between 3 and 10 miles per hour.
  - DO NOT spray during an inversion; only spray between one hour after sunrise and two hours before sunset.
  - Each product label requires a downwind 240-foot in-field spray drift setback (buffer) for all application sites
  - Each product label requires a downwind 310-foot in-field spray drift setback (buffer) for all application sites in areas of select counties as necessary to protect listed species.
- Volatile Emissions
  - XtendiMax® With VaporGrip® Technology must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.XtendiMaxapplicationrequirements.com.
  - Engenia® herbicide must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.engeniatankmix.com.
  - Tavium® herbicide must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.TaviumTankMix.com.
  - Application of products to soybean are prohibited after June 30 or after the soybean R1 growth stage.
  - Application of products to cotton are prohibited after July 30.
  - Each product label requires a 57-foot in-field, omni-directional, volatile drift setback (buffer) in identified counties with listed species.
- Runoff
  - DO NOT apply if soil is saturated with water or when rainfall that may exceed soil field capacity is forecasted to occur within 24-48 hours.
  - Under some conditions, dicamba has the potential for runoff several days after application. Poorly draining, wet, or erodible soils with readily visible slopes are more prone to produce runoff. When used on erodible soils or where adjacent to sensitive areas, best management practices for minimizing runoff should be employed.

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EPA structured this assessment of these products to address the potential risks to non-target organisms that are located in three areas: on the treated field, in near-field areas (areas adjacent to the treatment site), and in the surrounding broader landscape (wide-area). The assessment considered whether spray drift, volatility, and runoff control measures are adequate to address any potential risks in each of these areas. The assessment reflects review of a significant amount of scientific data including data obtained from the applicants/registrant, academia, and open literature as well as information provided by other stakeholders. Furthermore, the assessment considers and makes use of thousands of available incident reports that describe alleged dicamba-related symptomology observed at distances beyond the edge of treated field.

SUMMARY OF ECOLOGICAL RISK ASSESSMENT (NOT INCLUDING LISTED SPECIES EFFECTS DETERMINATIONS):

Table 1 summarizes EPA's assessment regarding risks to non-target non-listed taxa on and off the field from the use of the three products subject to the terms described above (includes control measures, as applicable).

EPA concluded that there are no risk concerns for aquatic plants or animals.

EPA's conservative screening level assessment indicates that there are no risks of concern for terrestrial animals from the inhalation of volatile emissions of dicamba. However, there are risks to non-listed non-target wildlife located on the treated soybean or cotton field. These include:

- acute dietary risk concerns for birds (on both treated soybean and cotton fields)
- chronic dietary risk concerns for birds[2] (treated soybean fields only), mammals (treated soybean fields only) and individual bees[3] and other terrestrial invertebrates (on both treated soybean and cotton fields)

Given the herbicidal mode action of these dicamba products, available laboratory toxicity endpoints, and intended effect of application at the treatment site, risk to nontarget plants <u>within</u> the confines of the treated soybean or cotton field is expected.

EPA's evaluation of the potential for off-field (near field and wide area) exposure to dicamba through spray drift and/or volatile emissions, taking into account the restrictions on the labeling, concludes the following about the potential risks to terrestrial non-target taxa located off the treated field:
- The mandatory spray drift control measures on the product labels, including the 240-foot downwind in-field spray drift set back eliminates risk concerns off the treated field for mammals, birds, terrestrial phase herpetic species, and terrestrial invertebrates. See **Section 1.6**.
- The same mandatory spray drift control measures eliminate risk concerns for non-target plant effects with a 90 percent certainty that these non-target organisms located off the field will not be exposed to dicamba from the use of these products. See **Section 1.7**.
- Because the sensitivity to dicamba of taxa other than non-target plants is lower, the distances to effects for animal taxa is less than for plants and so the certainty of protection for animal

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[2] And also reptiles and terrestrial-phase amphibians, for which birds are considered surrogates
[3] EPA does not have colony level data on these products.

taxa is greater than 90% when using the distances to plants to establish the efficacy of the in-field setbacks.

- The option to use an approved hooded sprayer technology on DT soybean crops along with an in-field downwind spray drift setback can also address spray drift. Field studies conducted on bare soil and soybean crops indicated that the use of a particular hooded sprayer (RedBall 642E) addressed potential spray drift exposures. Based on analysis in **Appendix O**, the 240 foot in-field spray drift setback can be reduced to 110 feet and still be protective of non-listed plant species. It should be noted that these trials did not evaluate the use of other sprayers (alternative hooded broadcast, hooded in-row and layby sprayers) nor did they evaluate the use of a hooded sprayer over cotton crops. As a result, the reductions in buffer distance permitted when using hooded sprayers is limited to soybean crops and this one currently approved technology. Alternative hooded sprayer technologies need to be tested under the EPA approved protocol to determine whether they can be approved for use. These approvals will be updated on the product websites. See **Section 1.7**.
- EPA evaluated the label statements that include the use of drift reduction agents. Most of the field studies (88%) EPA used to establish distance to effects for spray drift included the use of a drift reducing agent (DRA). Field studies demonstrate results are variable with the use of DRAs Based on the evaluated data, EPA concluded that a DRA does not need to be mandatory on the label. See **Appendix F**.
- EPA evaluated the mandatory label requirements to include volatility reduction agents (VRA) to address the issue of exposure to volatile emissions up to 160 feet from point of application. EPA determined that the inclusion of approved VRAs (without consideration of any additional restrictions) prevents damage from volatile exposures off the treated field with a high degree (89%) of certainty. See **Appendix F**.
- An evaluation of incident data, coupled with laboratory and field-based volatility data, shows that avoiding application when air temperatures are favorable to volatility would decrease the conditions that may have led to some dicamba-related non-target plant incidents. The imposition of the mandatory application cut-off dates (June 30th soybean, July 30th cotton) on the product labels reduces the probability of dicamba application on days more favorable for dicamba volatilization. See **Appendix I**.
- The mandatory runoff control measures on the labels reduce the risks to non-listed plants. See **Appendix G**.

EPA considers reduction in growth, survival and reproduction as regulatory endpoints. In this assessment, EPA evaluated a large number of studies from the registrants, academia, and weed scientists to determine the appropriate in-field setbacks to address the potential for off-field movement. In doing so, EPA determined the distance to effect for non-target organisms. In this evaluation, EPA conservatively selected 10% visual signs of injury (VSI) as a protective threshold which is expected to be protective against 5% reductions in plant height and yield with a high degree of certainty and to reasonably avoid the occurrence of off-field effects to non-target plants. Because other factors are important to the ultimate plant growth and yield relationship to observations of VSI, the (10% VSI) is not predictive of significant yield loss or growth impairment in non-target plants.

With respect to plants, the typical measurement endpoints based on laboratory studies report the measurement of survival, height and weight effects. However, for this assessment the best available data provides additional measurements specific to plant reproduction (yield) and visual signs of injury (VSI). EPA selected the measurement of VSI as an endpoint for two reasons: 1) to allow EPA to utilize the broadest range of available field effects data across a variety geographic areas, meteorological

conditions, and agronomic practices; and 2) to give meaningful weight to the observations of visual symptomology that form the majority of incident-reported plant observations associated with dicamba exposure. EPA recognized that the use of VSI must be placed in the context of traditional regulatory endpoints of survival, growth and reproduction.

To help inform the regulatory endpoint, EPA used the measurement of VSI to determine at the percentage of VSI at which there is a corresponding 5% reduction in plant height. EPA evaluated the association of the measurements of VSI, height, and yield responses to dicamba under both greenhouse and field conditions in studies submitted to EPA by registrants and academics. EPA found that the levels of VSI that correspond to a 5% reduction in height or a 5% reduction in yield are variable across the available data and are likely dependent upon soybean variety and field and agronomic factors. Ultimately, EPA determined that 10% VSI is a sensitive endpoint which is expected to be protective against 5% reductions in plant height and yield with a high degree of certainty. The 10% VSI is a conservative protective threshold for the most sensitive of plant species. Based on the available toxicity data, 95% of observed cases of VSI at exposures causing a 5% height or yield reduction were greater than 10%. The VSI endpoint is especially conservative for evaluating non-listed species under FIFRA, where the typical effect levels of concern are established at a higher 25% reduction of height, weight or survival.

As mentioned above **Table 1** provides the summary of RQs and risks for all taxa considered in **Section 1**.

Table 0. Summary of Risk Quotients for Non-listed Species from Labeled New Uses of Dicamba on DT-crops

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/Lines of Evidence	Do risks extend beyond the treated field with drift, volatility, and run-off control measures in Place for Non-Listed Species?[2]
Freshwater Fish	Acute	<0.01	No	--	Not applicable
	Chronic	<0.01	No	--	Not applicable
Estuarine/ Marine Fish	Acute	NC	No	RQs not calculated due to lack of mortality in acute studies.	Not applicable
	Chronic	<0.01	No		Not applicable
Freshwater Invertebrates (Water-Column and Sediment Exposure)	Acute	NC	No	RQs not calculated due to lack of mortality in acute studies.	Not applicable
	Chronic	<0.01	No		Not applicable
Estuarine/ Marine Invertebrates (Water-Column Exposure)	Acute	NC	No	RQs not calculated due to lack of mortality in acute studies.	Not applicable
	Chronic	<0.01	No		Not applicable
Mammals	Acute	0.01-0.04	No	No acute risk anticipated following either dietary or inhalation exposures	Not applicable
	Chronic	Dicamba-based <0.01-0.79 DCSA degradate-based <0.01-3.3	Yes (DCSA, soybean use only)	DCSA endpoint based on 9%↓ pup body weight at LOAEL of 78 mg/kg/d. No exceedances when compared to LOAEL or BMDL$_5$.	No (risks are limited to treated soybean fields as the DCSA degradate is a product of dicamba resistant crop metabolism)
Birds	Acute	<0.01-2.1	Yes	Exceedances of acute non-listed species LOC for small birds feeding on all exposed dietary items except fruits/pods/seeds and granivores and medium birds feeding on either exposed short grass or broadleaf plants.	No (available modelling of exposures for animals, with control measures in place, indicates risks do not extent off the field.)

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/Lines of Evidence	Do risks extend beyond the treated field with drift, volatility, and run-off control measures in Place for Non-Listed Species?[2]
Bees	Chronic	*Dicamba-based* 0.02-0.35 *DCSA-based* <0.01-1.7	Yes (DCSA, soybean use only)	DCSA endpoint based on applying a 17x toxicity differential between chronic mammalian dicamba and DCSA endpoints to the chronic avian dicamba-based endpoint.	No (risks are limited to treated soybean fields as the DCSA degradate is a product of dicamba resistant crop metabolism)
	Acute Adult	NC	N/A	No mortality in acute contact study. A screen of adult acute oral data submitted for dicamba registration review suggests there are no acute oral risks.	Not applicable
	Chronic Adult	0.85	No	Chronic endpoint based on 24%↓food consumption at LOAEC of 33 µg a.e./bee/day.	Not applicable
	Acute Larval	NC	N/A	A review of larval acute oral data submitted for dicamba registration review suggests there are no acute oral risks.	Not applicable

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Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/Lines of Evidence	Do risks extend beyond the treated field with drift, volatility, and run-off control measures in Place for Non-Listed Species?[2]
Other (non-bee) Terrestrial Invertebrates	Chronic Larval	1.3	Yes	Chronic endpoint based on 28%↓ adult emergence at LOAEC of 10 μg a.e./larva/day which is above the max estimated exposure of ~7 μg a.e./bee/day. All resides supporting the pollinator assessment are based on conservative default assumptions. Cut-off dates for soybeans reduce risk further for as it is likely that any risks to larval bees from exposed pollen and nectar do not persist for long periods of time (and relatively fewer soybean flowers may be in bloom at this time, further decreasing potential risks). Given that cotton is an indeterminate blooming crop, the degree to which this restriction may reduce the temporal extent of risk to larval bees is uncertain.	No (risk concerns are limited to larva of colonies with bees foraging on the treated field, itself)
	Acute	NC	N/A	Based on acute bee data, acute risks to terrestrial invertebrates are considered unlikely.	Not applicable
	Chronic	1.9-2.4	Yes	Chronic risks based on using honeybee larval endpoint when exposures are based on either insect residue or vegetation residue estimates.	No
Vascular Aquatic Plants	N/A	<0.01-0.24	No		Not applicable
Non-Vascular Aquatic Plants	N/A	0.49—0.79	No		Not applicable

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Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/Lines of Evidence	Do risks extend beyond the treated field with drift, volatility, and run-off control measures in Place for Non-Listed Species?[2]
Terrestrial Plants	N/A	NC	N/A, risk assumed to non-listed plant species	A refined assessment was conducted using large field-scale data to determine the distance from treated fields where plant effects are reasonably expected to occur. Consideration was given to the available data including registrant and academic field studies as well as incident information. Risk is assumed for any terrestrial plants on the treated field.	Spray Drift – No with 90% certainty of protection of non-listed plants using conservative effects endpoints (see special discussion of endpoints at end of this Volatility - No, with 89% certainty of protection of non-listed plants using conservative effects endpoints (see special discussion of endpoints) Runoff – Yes. Label requirements regarding soil moisture and rain-restrictions reduce this potential but do not eliminate it.

- Level of Concern (LOC) Definitions: Terrestrial Vertebrates: Acute=0.5; Chronic=1.0; Terrestrial Invertebrates: Acute=0.4; Chronic=1.0; Aquatic Animals: Acute=0.5; Chronic=1.0; Plants: 1.0
- [1] RQs reflect exposure estimates for dicamba and maximum application rates allowed on labels.
- [2] Control measures are listed as requirements labels as described in the Executive Summary.

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SUMMARY OF ENDANGERED SPECIES ACTION EFFECTS DETERMINATION CONCLUSIONS

EPA's ESA effects determination assessment evaluated whether there is a reasonable expectation that this federal action would pose any discernible effects to listed species as well as any designated critical habitats within the action area. For this Federal Action, as described in **Section 2**, EPA made no effects determinations for 22 of the 23 listed species and 1 critical habitat that overlap with the action. There was one listed species within the action area, the Eskimo curlew where EPA made a May Effect but Not Likely to Adversely (NLAA) Effect determination. EPA initiated informal consultation with the United States Fish and Wildlife Service (USFWS). USFWS has concurred on the NLAA determination.

In conducting this effects analysis, EPA used the methods described in the EPA's Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency: Endangered and Threatened Species Effects Determinations (USEPA 2004), and relied on location information provided by the USFWS and National Marine Fisheries Service (NMFS), collectively referred to as the Services, for the purposes of establishing whether listed species and their designated critical habitats occur within the action area of these registration actions. EPA also relied on Services' published materials (e.g., recovery plans) describing the biology and behavior or species and the characteristics of their designated critical habitats.

EPA used the best available scientific information related to dicamba effects on non-target plants and animals. These include relevant: 1) pesticide registrant data submissions, 2) published scientific literature, 3) submissions to the EPA from various academic researchers, and 4) non-governmental organization submissions. Where applicable, EPA began its assessment by relying on conservative taxa-specific risk assessment methods and their associated conservative assumptions regarding pesticide exposure and organism biology and behavior to identify taxonomic groups of non-target organisms that either 1) are not reasonably expected to be affected by the federal action or 2) require additional evaluation in a more biologically accurate and exposure appropriate species specific quantitative evaluation.

As noted above in the non-listed species risk summary presented in **Table 1**, taxonomic groups considered unaffected by the federal action include the aquatic taxa: fish and amphibians, invertebrates, and multicellular plants. Table 1 identifies aquatic unicellular plants as a possible taxon for additional evaluation for effects to listed species, however unicellular plants are not identified by the Services' listings of listed species so no further effects determination refinement efforts were appropriate for this taxon. Table 1 also identifies terrestrial mammals and birds (and reptiles as well terrestrial phase amphibians), and terrestrial invertebrates were identified as taxa requiring further consideration in the effects determination process. For these animal taxa, as described in **Section 2**, EPA defined the action area, after considering the control measures on the product labeling.

Data indicated that, without the mandatory control measures on the product labels, effects may have extended beyond the treated field. EPA reached this conclusion after consideration that 1) non-monocot plants were the most sensitive taxa to dicamba exposure and likely to drive the extent of the action area, 2) the large number reports of plant incidents related to alleged off-field dicamba exposure, and 3) the availability of a large body of evidence characterizing the plant effects when exposed to dicamba through spray drift and volatile emissions.

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For this ESA assessment, EPA evaluated control measures against the following criteria:

- whether there was any discernable effect to species or habitat using at least 95% certainty of no effects when considering all mandatory control measures
- quantitatively assess effects related to growth, survival, and reproduction
- consideration of incident Information
- whether the mandatory control measures addressed any wide area effects.

Taking into account the mandatory control measures on the labels, EPA evaluated the potential for off-field (near field and wide area) transport of dicamba by spray drift and volatility. EPA concluded the following about the potential risks to listed taxa located off the treated field (outside the defined action area):

- The mandatory 310 feet in-field downwind spray drift setback to address spray drift achieved a 95% probability that the action area is limited to the treated field in counties where required. Therefore, there are no discernible effects (level below the 10% VSI or 5% height reduction endpoints) for listed species off of the treated field. See **Section 1.7**.
- If an approved hooded sprayer is used (optional, not mandatory on the labels), EPA determined that the in-field downwind spray drift setback could be decreased from 310 feet to 240 feet, and still result in no change to the action area, and no change to the effects determinations (see **Appendix O**).

EPA then considered the mandatory control measures on the labeling addressing volatile emissions. For the ESA analysis, EPA evaluated the combined volatile emissions control measures (volatility reducing agents (VRAs), application cut-off dates, and an in-field 57-ft omnidirectional volatile emissions application setback). The combined mandatory control measures results in a greater than 95% certainty that dicamba exposures remain on the treated field, and are below a level where there are any discernible effects (the 10% VS or 5% height reduction endpoints that define the effects threshold for listed plant species; see **Appendix J**). Moreover, these combined volatile emissions control measures also address concerns related to previously reported incidents and the potential for area wide damage discussed in **Section 1.7**. The requirement for the VRA addresses volatile emissions, and also addresses dicamba loading to the downwind atmosphere. Similarly, the application of cut off dates reduces applications when temperature conditions favor volatility, further reducing loading to the downwind atmosphere.

The addition of an in-field 57 ft omnidirectional volatility setback places the source of dicamba well within the boundaries of the treated field. This untreated area afforded by the setback provides an area for attenuation and infiltration of runoff which would serve to reduce the off-field transport of dicamba. This in combination with label instruction to avoid application to saturated soils, or within 48 hours of predicted rainfall events, supports EPA's reasonable conclusion that there are no discernible effects off-field from runoff in the 287 counties where the 57 ft setback is required. See **Section 1.7.5** and **Appendix G** for more details on runoff.

1. Ecological Risk Assessment (not Including Listed Species Effects Determinations)

1.1. Problem Formulation

Dicamba was first registered in the United States in 1967 and is widely used in agricultural, industrial, and residential settings. Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Dicamba controls annual, biennial and perennial broadleaf weeds in crops and grasslands, and it is used to control brush and bracken in pastures. Dicamba is formulated primarily as a salt in an aqueous solution. Supported forms are: dicamba acid (PC code 029801), dicamba dimethylamine salt - DMA (029802), diethanolamine salt (029803), dicamba sodium salt (029806), dicamba diglycoamine salt - DGA (128931), dicamba isopropylamine salt (128944) and dicamba potassium salt (129043).

This assessment is for Bayer's XtendiMax With VaporGrip Technology herbicide [EPA Reg. No. 264-1210 (56.8% diglycolamine salt of dicamba (DGA); PC code 128931), BASF's Engenia Herbicide [EPA Reg. No. 7969-472], and Syngenta's Tavium (A21472) Plus VaporGrip Technology herbicide [EPA Reg. No. 100-1623], for use on dicamba-tolerant soybean and cotton crops. Collectively, these products are referred to as "DT-crop dicamba products" throughout the assessment. Previous versions of these products, registered between 2016 and 2018 and cancelled in 2020, were formulated using the diglycoamine (DGA) and N,N-Bis-(3-aminopropyl) methylamine (BAPMA) salts of dicamba to reduce volatility and included use restrictions to allow postemergence use on DT crops. Other, older dicamba products (e.g. dicamba acid, and inorganic salts) are currently registered for use on a variety of crops, including as a pre-emergent use on non-DT soybean and cotton crops.

This assessment considers the labeled application scenarios which allow for 2 applications of 0.5 lbs acid equivalent (a.e.) dicamba per acre (0.5 lb a.e./acre) as a pre-plant "burndown", pre-plant, at-plant, or preemergence. The labels for XtendiMax and Engenia also allow for an additional 2 over-the-top post-emergence applications (in-crop) at 0.5 lbs a.e./A, whereas the Tavium label is restricted to only a single over-the-top post emergence application of 0.5 lbs a.e./A. The maximum annual application, from the labeled products and inclusive of other applied dicamba products, is not to exceed an annual maximum of 2.0 lb a.e./acre.

The discussion below contains a review of the large body of studies on dicamba products for use on DT-crops with and without the additional volatility reducing agent (VRA; a pH buffering agent). This assessment addresses risks to nontarget organisms in three spatial areas:
- Within the area of the application site (treated field)
- Immediately external to the treated field (near-field zone)
- Larger landscape-scale risks (wide-area zone)

The treated field is the area of DT-cropland receiving the application of DT-crop dicamba products. It is considered inclusive of any applicable mandatory control measures on the labels to address the potential for spray drift and volatile emissions of dicamba (*e.g.* in-field setbacks).

The near-field zone is the area surrounding the treated field that without adequate control measures may receive dicamba exposure via the drifting of spray droplets during and immediately after

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application (spray drift) as well as exposure to vapor phase dicamba that volatilizes from the treated field under favorable environmental conditions over more protracted time periods (vapor drift). After review of the available distance to effect studies conducted by the dicamba registrants and academic researchers, EPA determined that spray drift would be the dominant exposure route for the near-field zone. These same field studies also indicate that dicamba vapor drift may occur at the near-field zone. As noted previously, these studies did not take into account the control measures on the labels EPA is now assessing.

A review of the available field studies and use of EPA's spray drift modelling and vapor phase dispersion tools provide a high level of confidence in describing the distance to effects (without consideration of the mandatory control measures) in the near-field zone out to between 300 to 400 feet from the field edge, depending upon the nature of the exposure route (spray droplet drift vs vapor phase transport). These same tools allowed EPA to measure the efficacy of the mandatory control measures.

EPA also assessed the wide area zone of impact - the area where plant responses characteristic of dicamba exposure have been reported in incident reports at distances exceeding those observed in available field studies and suggested by available modelling tools. The Agency used available field studies (from both academic and registrant-submitted sources) that document situations where dicamba-consistent signs of plant symptomology were observed, unrelated to the field study applications of the herbicide. The largest body of evidence for such wide area effects came from reports submitted by the registrants in response to EPA's request to provide information under FIFRA Section 6(a)(2). These reports contained information on approximately 5600 off-target incidents (reported at various distances) for the years 2017 through 2019. The reports contain information that shows incidents that have occurred beyond the distances from treated fields, including the setback restrictions contained on earlier labeling for these products, intended to address spray drift and vapor drift routes of exposure.

Based EPA's spray drift analysis, the mandatory control measures address spray droplet fines that were associated with wide-area incidents (those occurring at distances of hundreds of feet from a known dicamba use site). EPA has concluded that it is more likely that there is vapor phase exposure associated with these distances, especially on large landscape scales beyond the 10 to 20-acre field scale used for distance to effects field studies. Therefore, EPA cannot definitively exclude the potential impact of vapor phase drift in the wide area zone based on an evaluation of the available large field off-field movement studies. Moreover, EPA cannot identify any single volatility control measure (e.g., volatility reducing agent, VRA) that is certain to prevent dicamba from transforming into its acid, that results in offsite volatilization. In scientific studies and open literature VRAs are often referred to as "pH buffering agents" or "pH buffers" or "buffering agents".

1.1.1. Mode Of Action

Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Like the phenoxy herbicides, dicamba mimics auxins, a type of plant hormone and causes abnormal cell growth by affecting cell division. Dicamba acts systemically in plants after it is absorbed through leaves and roots. It is easily transported throughout the plant and accumulates in new leaves.

Consistent with the previous assessments on dicamba products for use on DT-crops, EPA bridged the environmental fate and effects data used in this assessment across the dicamba acid and all of the

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supported dicamba salts (MRID 43288001). EPA established a strategy for bridging the environmental fate and effects data requirements for the dicamba sodium and potassium salts, dimethylamine salt (DMA), isopropylamine salt (IPA), diglycoamine salt (DGA) and N,N-Bis-(3-aminopropyl) methylamine salt (BAPMA) to the dicamba acid (USEPA 2016a[4]). Registrant submitted data indicate the dicamba salts are be rapidly converted to the free acid of dicamba. Additionally, the submitted effects data indicate equal toxicity of the acid and salts (based on acid equivalents). As a result, EPA determined that fate studies conducted with dicamba acid provide "surrogate data" for the dicamba salts and that toxicity data across the acid and salts could generally be combined (USEPA, 2005a, USEPA 2016a). Chemical structures of dicamba and dicamba salts are presented in USEPA, 2011a. Further details regarding fate and transport laboratory and field studies submitted for dicamba can be found in (USEPA, 2005 **(Appendix A)**.

1.1.2. Use Characterization

Bayer CropScience (BCS) and BASF have submitted applications for new dicamba products [M1768 Herbicide, EPA Reg. No. 264-1210 (RERN) (42.8% DGA salt of dicamba), Engenia Herbicide, EPA Reg. No. 7969- 472 (UTE) (60.8% BAPMA salt of dicamba), and Syngenta has submitted an amendment request to extend the expiration date for Tavium® Plus VaporGrip® Technology, EPA Reg. No. 100-1623 (17.7% DGA salt of dicamba and 24% S-metolachlor] for use on dicamba-tolerant soybean and cotton crops. These products are water-soluble formulations intended for control and suppression of many broadleaf weeds, woody brush and vines. **Table 1.1** presents the labeled application rates to the dicamba-tolerant soybean and cotton crops. Rates for dicamba salts are normalized to dicamba acid equivalent per acre (a.e./A).

Table 1.1. Pre-emergent and Post-emergent Application Rates for the Dicamba Products on DT-Crops.
Pre-emergent applications to cotton and soybean plants are already allowed under currently registered dicamba products

Crop	Maximum Individual Application Rate[3] lbs dicamba a.e./A		Number of Applications	Application instructions and intervals (days)	Max Annual Application Rate in lbs dicamba a.e./A/year		Application Method
Dicamba-tolerant soybean and cotton crops	Pre-emergence (pre-plant, at planting, or prior to crop emergence)[2]	0.5	2	Pre-plant, at planting, or prior to crop emergence.	1.0	2.0 total	Restricted to ground sprays only
	Post-emergence[1] (Preharvest)	0.5	2[4]	From emergence to 7 days prior to harvest, minimum 7 days between applications	1.0		

[1]- XtendiMax Herbicide with VaporGrip, Engenia Herbicide, Tavium Plus VaporGrip Technology
[2]- Registered uses
[3]- "Acid equivalent"
[4] Only a single post-emergent application is registered for the Tavium product

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[4] USEPA. 2016a. Memorandum: Dicamba BAPMA salt – Bridging Memorandum for Dicamba BAPMA Salt (Engenia) to Dicamba Acid and Dicamba DGA Salt. Signed December 20, 2016.

It is common for these products to be tank mixed with other pesticide products (such as glyphosate which has been registered for use on genetically modified glyphosate-resistant crop varieties) and non-pesticidal agricultural chemicals. To address any concerns with tank mixes that could affect spray drift or volatile emissions, the product labels require that applicators use only approved tank-mix partners from a list maintained by the registrants (*e.g.*, www.engeniatankmix.com, www.TaviumTankMix.com, or www.XtendiMaxapplicationrequirements.com).

The products are for use on dicamba-tolerant soybean and cotton only in the following states:

> Alabama, Arizona, Arkansas, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin. There are specific counties, 287 out of a total of 2671 or 13% of the total soybean acres and 15% of the total cotton acres include listed species for which stricter control measures are required on the labeling. See Section 2.2 for complete details.

1.2. Residues of Concern

The major degradate of toxicological concern produced under anaerobic conditions for dicamba products is 3,6-dichlorosalicylic acid (DCSA). DCSA is persistent, accounting for > 60% of the applied dicamba after 365 days of anaerobic incubation in a laboratory-based environment consisting of sediment and water phases (MRID 43245208). DCSA is also formed in aerobic soil under laboratory conditions at a maximum of 17.4 % of the applied parent. DCSA is not persistent when formed under aerobic conditions and degrades roughly at the same rate as the parent (8.2 days, MRID 43245207). DCSA was also found in the two acceptable field studies (MRIDs 43651405 and 43651407) in soil segments deeper than 10 cm and would likely be persistent in ground water. Other minor dicamba degradates are dichlorogentisic acid (DCGA) and 5-OH-dicamba, and both are less toxic than the parent and DCSA. The formation of DCGA in the laboratory studies did not exceed 3.64%, and the formation of 5-OH dicamba did not exceed 1.9 % in soil/water system during anaerobic aquatic degradation of dicamba under laboratory condition. DCSA was also a major metabolite in plant metabolism and magnitude of residue studies for dicamba-tolerant soybean and cotton. Toxicity data for DCSA in mammals have been submitted to the Agency. Based on available data, DCSA appears to be less toxic or equally toxic as the parent (see **Appendix B**) for aquatic organisms on an acute basis but may be substantially more toxic on a chronic basis to terrestrial organisms, specifically mammals (MRIDs 43137101 and 47899517).

Therefore, this assessment considers the parent and its degradate DCSA in the aquatic assessment (with the assumption that dicamba and DCSA are equally toxic), while the terrestrial assessment for mammals will consider parent dicamba and DCSA separately.

1.3. Environmental Fate Characterization

Dicamba is soluble (6,100 mg/L) and mobile (K_{oc} = 13.4 L/mg o.c.) in the laboratory, it is an anion at environmental pHs (pKa = 1.9) and is not expected to bioaccumulate in aquatic organisms. Dicamba is unstable to aerobic metabolism with half-lives on the order of days, while it is generally stable to abiotic processes, and it is generally more persistent under anaerobic conditions. Dicamba may reach surface water via run-off, by spray drift during application, and by vapor drift from volatilization (see analysis below in the volatilization characterization). Based on academic and registrant studies, incident data from 2017 to 2019, and the potential for increased volatility during warmer temperatures and in later season applications, EPA completed an analysis of drift from vapor volatilized from the treated field (see Section 1.7). Dicamba is less likely to be available to leach to groundwater because it is susceptible to aerobic degradation. However, any dicamba reaching groundwater would be somewhat persistent (due to its relative stability to hydrolysis).

Further details regarding fate and transport laboratory and field studies submitted for dicamba can be found in (USEPA, 2005; and USEPA 2016b).

1.3.1. Aquatic Exposure Estimates

EPA modeled likely surface water concentrations of dicamba acid and its major degradate DCSA using PWC (v1.5.2)[5] coupled with the standard pond scenario. EPA selected standard Mississippi soybean and cotton scenarios to assess runoff potential from vulnerable use sites. PWC scenarios are used to specify soil, climatic, and agronomic inputs in PRZM[6], and are intended to result in high-end water concentrations associated with a particular crop and pesticide within a geographic region. Each PWC scenario is specific to a vulnerable area where the crop is commonly grown. Soil and agronomic data specific to the location are built into the scenario, and a specific climatic weather station providing 30 years of daily weather values is associated with the location. EPA based the modeling scenario for DCSA on the following: (1) assuming 17.4% conversion from parent DCSA and (2) using molecular weight conversion to adjust from parent application rate to DCSA application rate. **Tables 1.2** and **1.3** list the input parameters EPA used for the PWC modeling of dicamba acid and DCSA degradate. EPA selected input parameters in accordance with EPA's guidance documents (USEPA, 2009; USEPA, 2010; USEPA, 2013b).

TABLE 1.2. PWC Inputs, Dicamba.

Parameter	Dicamba Value	Source / Comments
Molecular Weight (g/mol)	221	SANDOZ Safety Data Sheet (Nov, 1989).
Solubility @ 25°C (mg/L)	6100	SANDOZ Safety Data Sheet (Nov, 1989).
Vapor Pressure (torr)	3.41×10^{-5}	SANDOZ Safety Data Sheet (Nov, 1989).
K_{oc} (mL/g o.c.)	13.4	MRID 42774101 (average)
Hydrolysis (pH 7) half-life (days)	0	Stable. MRID 40547902
Aquatic Photolysis Half-life (days)	105	MRID 42774102. Adjusted half-life to represent sun intensity and 12 hours of sunlight per day. 38.1 day

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[5] USEPA. 2016d. Pesticide in Water Calculator User Manual for Versions 1.50 and 1.52
[6] USEPA. 2016e. PRZM5 A Model for Predicting Pesticides in Runoff, Erosion, and Leachate Revision A. USEPA/OPP 734S16001. May 12, 2016

Parameter	Dicamba Value	Source / Comments
		value represented continuous sun exposure at an intensity of 1.38 times natural sunlight.
Aerobic Soil Metabolic Half-life (days)	18	MRID 43245207; (6d x 3)
Aerobic Aquatic Metabolic Half-life (days)	72.9	MRID 43758509; 3x a single half-life value of 24.3 days
Anaerobic Aquatic Metabolic Half-life (days)	423	A single half-life value was available (MRID 43245208); 3x the half-life value (141 x 3 = 423)
Application rate (kg ai/hectare)	0.56	Label
Number of applications/year	4	Draft label
Interval between applications	7 days	Draft label
Application Method	Ground	Draft label
Scenario modeled (Metfile) - Initial Application Date	MScottonSTD (W03940.dvf) – 4/16 MSSoybeanSTD (W03940.dvf) – 4/2	Dates based on the crop profile, emergence date, and precipitation data.
Application efficiency	0.99	
Spray drift fraction	0	In-field downwind spray drift setback designed to eliminate drift impacts

TABLE 1.3. PWC Inputs, DCSA.

Parameter	DCSA Value	Source / Comments
Molecular Weight (g/mol)	207	Product chemistry
Solubility @ 25°C (mg/L)	2112	MRID 43095301
Vapor Pressure (torr)	3.41×10^{-5}	For dicamba
K_{oc} (mL/g o.c.)	1208	MRID 43095301 (average)
Hydrolysis (pH 7) half-life (days)	0	Stable. MRID 43245208
Aquatic Photolysis Half-life (days)	105	No data for DCSA; therefore, used value for dicamba.
Aerobic Soil Metabolic Half-life (days)	24.6	MRID 43245207; (8.2 d x 3)
Aerobic Aquatic Metabolic Half-life (days)	0	Stable. MRID 43245208
Anaerobic Aquatic Metabolic Half-life (days)	0	Stable. MRID 43245208
Application rate (kg ai/hectare)	0.097	17.4% of the labeled rate for dicamba
Number of applications/year	4	Label
Interval between applications	7 days	Label
Application Method	Ground	Label
Scenario modeled (Metfile) - Initial Application Date	MScottonSTD (W03940.dvf) – 4/16 MSSoybeanSTD (W03940.dvf) – 4/2	Dates based on the crop profile, emergence date, and precipitation data.
Application efficiency	1.0	
Spray drift fraction	0	Forms from degradation, no spray drift

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1.3.2. PWC Modeling Output

Table 1.4 presents PWC model-estimated concentrations of dicamba acid and DCSA degradate in surface water, commonly referred to as estimated environmental concentrations (EECs; USEPA 2004 V.B.4) for the applications for use on dicamba-tolerant soybean and cotton. EPA used these EECs to calculate risk to aquatic animals and plants. For soybean, the 1-in-10-year Daily Average, 21-day and 60-day EECs for dicamba-alone are 47.9, 46.2, and 42.9 µg a.e./L, respectively, and 3.90, 3.08, and 2.66 µg a.e./L, respectively, for DCSA. For cotton, the 1-in-10-year Daily Average, 21-day and 60-day EECs for dicamba alone are 29.6, 27.7, and 24.6 µg a.e./L, respectively, and 3.08, 2.70, and 2.21 µg a.e./L, respectively, for DCSA.

TABLE 1.4. PWC Estimated Environmental Concentrations (EECs) for Dicamba Acid and DCSA Degradate.			
	Estimated Water Concentrations (µg/L)		
Scenario	1-in-10-year Daily Average EEC	1-in-10-year 21-day mean EEC	1-in-10-year 60-day mean EEC
Dicamba			
MS Soybean – water column	47.9	46.2	42.9
MS Cotton – water column	29.6	27.7	24.6
DCSA			
MS Soybean – water column	3.90	3.08	2.66
MS Cotton – water column	3.08	2.70	2.21

It should be noted that these EECs include releases that occurred within 2 days of the application, and do not reflect the labeling requirements that applications are prohibited if the soil is saturated with water or when rainfall that may exceed soil field capacity is forecasted to occur within 48 hours. If the years where a release occurs within 2 days of application are removed from consideration, the 1-in-10-year Daily Average, 21-day and 60-day EECs for dicamba-alone for soybeans are 40.8, 39.2, and 35.4 µg a.e./L, respectively, and for cotton are 23.5, 22.2, and 20.0 µg a.e./L, respectively. As dicamba EECs were about an order of magnitude higher than the DCSA EECs, EPA did not conduct the same analysis for DCSA.

1.4. Terrestrial Exposure Estimates

Terrestrial wildlife exposure estimates for birds and mammals typically focus on the dietary exposure pathway (USEPA, 2004). This risk assessment considers this route of exposure as well as potential exposures to spray droplet inhalation or vapor-phase exposure. Potential dietary exposure for terrestrial vertebrate wildlife in this assessment is based on consumption of dicamba and DCSA residues on food items following spray (foliar) applications. For parent dicamba, EPA calculated EECs for birds[7] and mammals from consumption of dietary items on the treated field using T-REX v.1.5.2[8]. EPA calculated potential exposure of these taxa to spray droplet inhalation or vapor-phase dicamba exposures using the STIR v1.0 tool[9]. EPA evaluated chronic exposure for terrestrial vertebrates exposed

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[7] Birds are also used as a proxy for reptiles and terrestrial-phase amphibians.
[8] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#t-rex
[9] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#stir

to dietary items on the treated field containing the metabolite DCSA using empirical data described below.

EPA calculated exposures to bees using the BeeREX v1.0 tool while for other terrestrial invertebrates EPA estimated the on-field screening exposure through application of the T-REX model, estimating a pesticide concentration in insects following exposure to direct pesticide spray or any residues ingested from exposed diet. The risk assessment section on bees and other terrestrial invertebrates (**Sections 1.6.3** and **1.6.4**) describes the exposure assessment and risk characterization for this taxon in more detail.

EPA conducted the terrestrial plant exposure and ecological risk assessments using a refined methodology discussed in **Section 1.7.**

1.4.1. Parent Dicamba Exposure Estimates for Terrestrial Vertebrate Dietary Items on the Treated Field using Chemical-specific Half-Lives

EPA modeled the dicamba residues on the field following spray applications using two pre-emergent 0.5 lb a.e./A and two post-emergent 0.5 lb a.e/A applications with a minimum seven-day retreatment interval between each. EPA modeled residues using a refined chemical-specific foliar dissipation half-life value for parent dicamba.

EPA used residue data by Jimenez (1994; MRID 43370701) to calculate a dicamba specific foliar dissipation half-life. According to the available Health Effects Division (HED) review (DP Barcode 207649, 3/11/1996), this study was acceptable for use in risk assessment and indicated that there was no difference in foliar dissipation data between the various tested dicamba salt formulations (DMA, DGA and sodium salt formulations). Therefore, EPA used data for all dicamba salt formulations tested to calculate the final foliar half-life value.

EPA calculated half-lives for each set of residue decline data based on the *NAFTA Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media* and using the PestDF package in the R statistical program. EPA evaluated each equation for appropriateness before inclusion in the final half-life calculation. A summary of decline data and estimated foliar half-life values from this study is provided in the **Table 1.5** below. EPA used the upper 90th percentile, one tailed, confidence interval of 8.4 days to calculate refined EECs in this assessment.

Table 1.5. Dicamba Half-Life (days) in Foliage					
Arithmetic Mean	Standard Deviation	Max Value	Min Value	Number of Values	Upper 90% CL on the mean
7.3	6.6	43.7	1.11	99	**8.4**

EPA derived exposure estimates for terrestrial animals assumed to be in an area exposed to spray drift using the T-REX (Terrestrial Residue EXposure model) model (version 1.5.2). This model incorporates the Kenaga nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represent an approximation of the highest residue value observed in the data set (Hoerger and Kenaga 1972). Consideration is given to different types of feeding strategies for mammals and birds; including herbivores, insectivores and granivores. For

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dose-based exposures, three weight classes of birds (20, 100, and 1000 g) and mammals (15, 35, and 1000 g) are considered. EPA used the dicamba-specific foliar dissipation half-life of 8.4 days for risk estimation. The assessment assumes a maximum single application rate of 0.5 lb a.e./A, 4 applications and a 7-day application interval to estimate terrestrial exposures of dicamba. The dose- and dietary-based EECs (upper bound Kenaga) on a variety of food items from the use of dicamba applied at the maximum labeled rates is provided below in **Table 1.6**, along with the full T-REX inputs and output. Consideration is given to different types of feeding strategies for mammal and birds, including herbivores, insectivores and granivores. EPA estimated dose-based exposures for three weight classes of birds (20 g, 100 g, and 1,000 g) and three weight classes of mammals (15 g, 35 g, and 1,000 g). As the use rates are the same for dicamba products applied to either DT-soybean or DT-cotton, EPA predicts on-field residues to be identical.

Table 1.6. Summary of Dietary (mg a.e./kg-diet) and Dose-based EECs (mg a.e./kg-bw) as Food Residues for Terrestrial Vertebrates from Labeled Uses of Dicamba Products on Dicamba-Tolerant Crops (T-REX v.1.5.2, Upper-Bound Kenaga).

| Food Type | Dietary-Based EEC (mg/kg-diet) | Dose-Based EEC (mg/kg-body weight) | | | | | |
| | | Birds | | | Mammals | | |
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Dicamba-tolerant soybean and cotton max annual ground (4x 0.5 lb a.e./A, 7-d interval)							
Short grass	250	280	160	72	230	160	38
Tall grass	110	130	73	33	110	74	17
Broadleaf plants/small insects	140	160	90	40	130	91	21
Fruits/pods/seeds (dietary only)	15	18	10.0	4.5	15	10	2.4
Arthropods	96	110	63	28	92	64	15
Seeds (granivore)[1]	N/A	3.9	2.2	0.99	3.3	2.3	0.52

[1] Seeds presented separately for dose – based EECs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

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1.4.2. Inhalation of Spray Droplet/Vapor-Phase Inhalation Exposure Assessment

EPA also evaluated the potential for risk to terrestrial vertebrates through inhalation exposure. EPA used the Screening Tool for Inhalation Risk (STIR v.1.0) to assess the potential for risk to birds and mammals through inhalation exposure. The exposure pathways that are assessed by this tool include both droplet inhalation and vapor-phase inhalation. STIR is intended to determine if exposure is likely or not and whether the potential for risk exists based on a chemical's maximum application rate, molecular weight and vapor pressure and the available mammalian acute oral and inhalation toxicity endpoints and avian acute oral endpoint (an adjusted avian inhalation toxicity endpoint is estimated from the mammalian toxicity data). If STIR predicts that exposure is likely, additional inhalation data may be necessary to adequately assess risk due to the inhalation exposure pathway. Using the maximum single application rate of 0.5 lb a.i./A, the maximum vapor concentrations at saturation, and maximum vapor inhalation and spray inhalation doses are shown in **Table 1.7**. See **Appendix M** for STIR inputs and outputs.

Table 1.7. Estimated Vapor-Phase and Spray Inhalation Exposure Values for On-field Birds and Mammals

Assessed Taxa	Maximum Vapor Concentration (mg/m³)	Maximum 1-hr Vapor Inhalation Dose (mg/kg)	Maximum Post-treatment Spray Inhalation Dose (mg/kg)
Small (20 g) bird	0.41	0.051	0.053
Small (15 g) mammal	0.41	0.064	0.066

1.4.3. Metabolite DCSA Exposure Analysis for Terrestrial Vertebrate Dietary Items on the Treated Field

The available data indicate that in mammals, DCSA has similar acute toxicity as parent dicamba, but is substantially (17x) more toxic on a chronic basis. DCSA residues following dicamba applications prior to planting conventional cotton and soybean plants are generally considered negligible and would not be of concern (USEPA, 1983 and 1984) due to the low levels of DCSA that form in non-DT plants (*see below*). However, in dicamba-tolerant plants, DCSA forms in much greater amounts (*see below*; MRIDs 43814101 and 44089307 for DT-soybeans; MRIDs 48728701 & 48728703 for DT-cotton) than in non-DT plants. Based on the available data, EPA evaluated the DCSA metabolite separately from parent dicamba in the chronic terrestrial ecological risk assessment. Based on the available plant metabolism data for DCSA on conventional (non-DT) plants, EPA assumed that any exposure for terrestrial vertebrates occurs as a result of feeding solely on DCSA in DT-cotton and DT-soybean fields and no exposure to DCSA is expected for terrestrial vertebrates feeding off the field, even if dicamba residues should occur following spray drift or volatilization because non-DT plants do not contain the modified gene that confers dicamba tolerance on DT-plants allowing the DT-plants to convert dicamba residues to form the less phytotoxic DCSA.

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1.4.3.1. DCSA Residues in DT-Soybean Plants

In conventional soybean plants, DCSA residues following dicamba applications prior to planting were less than 2% of total dicamba residues in forage, hay and seed (MRIDs 43814101 and 44089307; maximum of 0.130 ppm DCSA, see **Appendix N**) and would not be above toxicity thresholds for any taxa. However, in dicamba-tolerant soybean plants, dicamba is converted to DCSA and its glycosidic conjugates following demethylation of the aromatic methoxy moiety of dicamba (USEPA, 2013a. HED residue chemistry summary). This is in contrast to dicamba use on conventional soybeans which lack the means to metabolize dicamba to DCSA. Therefore, residues of DSCA in DT-soybeans and DT-cotton are higher than in non-DT soybeans and cotton (**Appendix N** and MRIDs 47899524, 48219901). The empirical data from MRID 47899524 found maximum (across 44 trials), DCSA concentrations of 51.3 ppm, in forage 7-10 days following the last application, 61.1 ppm in hay 13-15 days following the last application and 0.440 ppm in seeds 73-98 days after the last application. EPA used these maximum measured values from the empirical data to assess risk to terrestrial vertebrate herbivores and granivores. There is some uncertainty in this approach as the maximum DCSA residues appear to be slightly increasing (16%) between forage at 7-10 days and hay at 13-15 days, however this could be due to the difference between fresher forage and drier hay, where DCSA has become more concentrated compared to the overall plant biomass, rather than due to additional conversion of dicamba residues to DCSA. Additionally, the amount of additional dicamba available to potentially convert to DCSA appears limited after this point as the maximum residues of dicamba were only 2.62 and 1.16 ppm in forage and hay, respectively.

DCSA residues are expected to be negligible off the field as non DT-plants lack the modified gene(s) to convert dicamba to the less phytotoxic DCSA. For example, in conventional soybeans, the maximum DCSA residues were only 0.130 ppm in soybean seeds (MRIDs 43814101, 44089307) following dicamba treatments (total 2.5 lb ae/A). Similarly, in conventional asparagus plants, the maximum DCSA residues were 0.071 ppm following a single 0.5 lb ae/A dicamba application (MRIDs 43245206 and 43425803)

1.4.3.2. DCSA Residues in DT-Cotton Plants

Appendix N shows residues of dicamba and its metabolites in cotton plants following a number of different treatment regimes (data from MRIDs 48728701 & 48728703). The highest residues for both dicamba and its metabolite DCSA were found in cotton gin byproducts following TRT 4 (4 post-emergent applications of 0.5 lb/A for a total seasonal application rate of 2.0 lb/A, 13 independent trials) where maximum DCSA residues were approximately 21% of the maximum total dicamba-related residues (6.29 ppm DCSA compared to 23.6 ppm dicamba) while undelinted cotton seed had substantially less residues (0.27 ppm DCSA and 1.54 ppm dicamba). EPA used the maximum values for DCSA from the empirical data on gin byproducts and undelinted cotton seeds (6.29 and 0.27 ppm, respectively) to assess risk from DCSA residues following post-emergent applications of dicamba on DT-cotton plants to terrestrial vertebrates. Gin byproducts (*i.e.* unused cotton plant parts following harvest) for cotton can include a number of different plant parts including fragments of burs, stems and leaf material and immature cottonseed. Since gin byproducts can include immature seeds which may lower the average DCA concentration of gin byproducts (since the mature seeds had very low measured DCSA residues), it is possible that the maximum DCSA residues in cotton plant tissues may be slightly higher than in gin byproducts. Additional data on the distribution of DCSA residues in the various cotton plant parts (*e.g.* stem, leaves) over a broader temporal range would decrease this uncertainty. However, the best available data indicate that DCSA is a much smaller fraction of dicamba related residues in the DT-cotton

system compared to the DCSA and dicamba residues in the DT-soybean system described above, and using the maximum empirical residues is considered a conservative approach. For the same reasons noted above for DCSA residues in plants off the treated soybean field, EPA anticipates DCSA residues in plants off the treated cotton field to be negligible.

1.5. Environmental Effects Characterization

An effects characterization describes how toxic a pesticide is to different organisms and/or to other ecological entities (e.g., community), what effects it produces, how the effects relate to the assessment endpoints, and how these effects change with varying levels of pesticide exposure. This characterization is based on a stressor-response profile that describes how toxic a pesticide is to various plants and animals, the cause-and-effect relationships, how fast the organism(s) recovers, relationships between the assessment endpoints and measures of effect, and the uncertainties and assumptions associated with the analysis.

EPA estimates the toxicity or hazard of a pesticide by evaluating ecological effects tests that vary from short-term (acute) to long-term (chronic) laboratory studies and may also include field studies. In these tests, animals and plants are exposed to different amounts of pesticides, and their responses to these varying concentrations are measured. The results of these tests may be used to establish a dose-response or cause-and-effect relationship between the amount of pesticide to which the organism is exposed and the effects on the organism. To evaluate acute effects to animals, the endpoints typically used are lethality-based such as the median lethal dose or concentration (LD_{50} or $LC_{50)}$, which is a regression-based estimate from the dose-response profile to describe the amount or dose of a chemical which kills 50% of the exposed animals. To evaluate chronic effects to animals, the endpoints typically used are based on significant effects directly relating to an organism's fitness in the environment (*i.e.* apical effects reducing an organisms' survival, reproductive capacity and/or physiological growth; USEPA, 2004). The NOEL (no observed effect level) or the NOEC (no observed effect level) has been defined in USEPA (2004) as the highest concentration of a chemical in a toxicity test that has no significant adverse effect on the exposed population of test animals. In this document, EPA refers to these endpoints more precisely as the NOAEL/NOAEC (No Observed Adverse Effect Level or Concentration) to more appropriately include the adverse effect term of the original definition of NOEL/NOEC. For aquatic plants, the relevant ecological endpoints are the IC_{50} (regression-based estimate that describes the amount of chemical which inhibits a plant's growth, survival or reproduction-based endpoint by 50%) and the NOAEC (or IC_{05} where a NOAEC cannot be calculated). The IC_{05} is a regression-based estimate that describes the amount of chemical which inhibits a plant's growth, survival or reproduction-based endpoint by 5%. Owing to a more comprehensive risk assessment methodology for terrestrial plants, the ecological effects and endpoints used for this taxon are discussed in detail in **Section 1.7**.

In most cases, toxicity tests are conducted on an active ingredient basis. If formulated product effects data are available, they will also be considered in the risk assessment. In addition, data on degradates of potential toxicological concern will be incorporated into the risk assessment. In this testing system, surrogate or substitute organisms are used to represent a group of organisms. For example, the laboratory rat may be used to represent all mammalian species.

Ecological effects data are used to estimate the toxicity of dicamba and its metabolite DCSA to surrogate species. The aquatic and terrestrial effects endpoints utilized in the risk assessment are summarized briefly in **Table 1.8** below and Sections 1.5.1 and 1.5.2, and are discussed in more detail in **Appendices B and C.**

TABLE 1.8. Toxicity Values Used to Assess Risks from Use of Dicamba on DT-Crops.

SPECIES	ACUTE ENDPOINT	Chronic Endpoint	MRID[1]
Freshwater Fish	LC_{50} = 28,000 µg a.e./L	NOAEC = 9,700 µg a.e/L	40098001, 48718008
Estuarine/Marine Fish	LC_{50} > 180,000 µg a.e./L	NOAEC = 11,000 µg a.e./L	00025390, 48718011
Freshwater Invertebrates	EC_{50} > 100,000 µg a.e./L	NOAEC = 42,000 µg a.e./L	40094602, 48718007
Estuarine/Marine Invertebrates	EC_{50} > 100,000 µg a.e./L	NOAEC = 11,000 µg a.e./L	00034702, 48718012
Aquatic Vascular Plants	IC_{50} > 3,250 µg a.e./L	NOAEC = 200 µg a.e../L	42774111
Aquatic Non-Vascular Plants	IC_{50} = 61 µg a.e./L	NOAEC = 5 µg a.e./L	42774109
Birds	LD_{50} = 188 mg a.e./kg-bw LC_{50} > 10,000 mg a.e./kg-diet	NOAEC = 695 mg a.e./kg-diet	42918001, 00025391, 43814003
Mammals (parent dicamba; oral exposure)	LD_{50} = 2,740 mg a.e./kg-bw	NOAEL = 136 mg a.e./kg-bw	00078444, 43137101
Mammals (parent dicamba; inhalation exposure	LC_{50} > 5.3 mg a.e./L	N/A	00263861
Mammals (metabolite DCSA)	LD_{50} = 2,641 mg a.e./kg-bw	NOAEL = 8 mg a.e./kg-bw	47899504, 47899517
Terrestrial Invertebrates	LD_{50} > 91 µg a.e./bee (adult contact)	NOAEC = 19 µg a.e./bee/d (adult chronic) NOAEC = 5.1 µg a.e./bee/d (larval chronic)	00036935, 50784603, 50784602
Terrestrial Plant Taxa[1]	**Non-listed Species Endpoint**	**Listed Species Endpoint[1]**	**MRID**
Dicot (Soybean, *Glycine max*) – Vegetative Vigor	EC_{25} = 0.000513 lbs ae/A	NOAEC = 0.000261 lbs ae/A	47815102
Monocot (Onion, *Allium cepa*) – Vegetative Vigor	EC_{25} = 0.472 lbs ae/A	EC_{05} = 0.137 lbs ae/A	47815102

[1] Terrestrial plant data, including discussion of the listed species endpoints, are discussed in depth in the terrestrial plant risk assessment (**Section 1.7; toxicity studies are described in Appendix C**).

1.5.1. Aquatic Toxicity

Based on the available ecotoxicity data information, on an acute exposure basis, dicamba is practically non-toxic to freshwater and estuarine/marine and freshwater fish, and practically non-toxic to slightly toxic to freshwater and estuarine/marine invertebrates. Chronic data indicate that chronic effects to aquatic taxa occur at levels up to an order of magnitude below any acute effects. For aquatic plants, dicamba appears to be more toxic to non-vascular plants than to vascular plants. No acute or chronic

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aquatic toxicological data reviews were available for dicamba's metabolite, DCSA, though the EU's footprint database[10] reports similar acute toxicity of DCSA to parent dicamba and significantly lower toxicity of DCSA to aquatic plants.

1.5.2. Terrestrial Toxicity

On an acute oral basis, the avian toxicity of dicamba ranges from practically non-toxic to moderately toxic. On an acute dietary basis, treatment-related effects and mortalities were generally not observed in birds even at the highest tested doses, leading to non-definitive (*i.e.* no mortalities were observed at the highest tested doses) LC50s. The only sensitive chronic avian endpoint was for mallard ducks (21-week NOAEC of 695 mg a.e./kg-diet) which is based on moderate (11-21%) reductions in the number of hatchlings, 14-day old chicks and 14-day old chicks as a percentage of eggs laid in the 1390 mg a.i./kg-diet treatment group compared to the control group. However, these reductions were not statistically significant and potentially could be due to natural variability. Therefore, it is possible that this endpoint may overestimate the chronic toxicity of dicamba to avian species.

Dicamba is practically non-toxic to mammals on acute oral basis. Chronic effects observed in the 2-generation rat study were based on neurotoxicity, delayed maturation of the initially exposed F0 generation, and decreased pup weight in both the succeeding F1 and F2 generations at 450 mg a.e./kg-diet.

Dicamba is practically non-toxic to adult honeybees on an acute contact exposure basis. As part of registration review, the full suite of honeybee Tier I laboratory studies have recently been submitted. For this risk assessment, EPA screened these data to determine if any of it might impact the terrestrial invertebrate risk assessment. Based on the lack of effects reported in the submitted adult and larval acute oral data, EPA did not consider these data further in this risk assessment. Due to observed effects in the submitted adult and larval chronic studies (MRIDs 50784603 and 50784602, respectively), EPA prioritized these studies for review for use in the risk assessment for the DT-crop dicamba products. Chronic exposure of adult bees to dicamba resulted in reduced food consumption (24%, relative to controls) at 33 μg a.e./bee. It is possible that some of this effect is a result of the solvent used in the test, rather than dicamba itself, as the solvent control had significantly lower food consumption (40%), compared to the negative control. However, as a clear dose-response relationship with food consumption was observed in the treatment groups, this effect was not discounted. Further, an additional chronic dicamba on adult bees (MRID 50931304) also showed impacts on food consumption at higher doses. In a chronic larval bee study, significant impacts to pupal mortality (29% inhibition, relative to controls at D15) and reduced adult emergence (28% inhibition at test termination on D22) were observed following repeat dose (4-days) exposure at 10 μg a.e./larvae/day. No tier II data effects (*i.e.* colony feeding or tunnel studies) or exposure (*i.e.* empirical residues in treated soybean or cotton floral parts) data are available.

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[10] Pesticide Properties Database (PPDB) (http://sitem.herts.ac.uk/aeru/footprint/en/index.htm).

1.5.2.1. DCSA Metabolite Effects to Terrestrial Vertebrates

A rat 2-generation study with DCSA (MRID 47899517) observed statistically significant decreases (6-9%) in offspring weight on 14 and 21 post-natal days (PND). EPA's review concluded that the is NOAEL of 4 mg/kg/d with effects to pup weight occurring at 37 mg/kg/d. A subsequent benchmark dose analysis conducted by HED (USEPA, 2016c) determined BMD_5 (estimated benchmark dose (BMD) to result in 5% body weight change in pups from background levels) and $BMDL_5$ (the lower 95% confidence level on the BMD_5) based on both the male pre-mating dose and the female lactation dose and noted that female lactation doses are more reflective (than male-premating doses) of pup exposure during the nursing period when the pup body weight decreased. This analysis concluded that the pup weight LOAEL and NOAEL threshold values based on the dam lactation doses would be 78 mg/kg/d and 8 mg/kg/d, respectively. HED also calculated a BMD_5 (estimated benchmark dose to result in 5% body weight change in pups from background levels) and $BMDL_5$ (the lower 95% confidence level on the BMD_5) of 38.6 and 34.9 mg/kg/d, respectively, based on the female lactation doses. In the analysis presented in this document, EPA used the NOAEL value of 8 mg/kg/d for risk estimation and further characterized the risk using the $BMDL_5$ of 34.9 mg/kg/d and other relevant information for DCSA effects to mammals.

As is common with degradates, there are no chronic data are available for the effects of the DCSA degradate to birds (or reptiles or terrestrial-phase amphibians, for which birds are surrogates). EPA therefore took a highly conservative approach, where the Agency considered the toxicity differential for chronic effects between parent dicamba and the metabolite DCSA and applied a similar ratio to estimate chronic effects to avian organisms. Therefore, EPA applied a factor of 17x (based on the chronic endpoints of 136 mg/kg-bw for parent dicamba and 8 mg/kg-bw for DCSA) to the dicamba chronic NOAEC of 695 mg/kg-diet for the mallard duck, to result in a highly conservative estimate of a chronic NOAEC of 40.9 mg/kg-diet for birds for DCSA. This is considered a highly conservative approach as the chronic mammalian endpoint is based on effects to pups who would have been continually exposed to DCSA residues in utero and throughout lactation while chicks in the avian reproduction test would not be exposed to any additional DCSA residues while still in the egg or post hatch beyond what are already in the egg itself at the time of egg-laying.

1.6. Risk Estimation and Characterization

The screening ecological risk assessment generates a series of risk quotients (RQs) for broad taxonomic groups (e.g., mammals, birds, fish, etc.) that are the ratio of estimated exposures to acute and chronic effects endpoints (USEPA, 2004). EPA then compares these RQs to EPA established levels of concern (LOCs) to determine if risks to any taxonomic group are of concern. The LOCs address risks for both acute and chronic effects. Acute effects LOCs range from 0.05 for listed aquatic animals to 0.5 for aquatic non-listed animal species and 0.1 to 0.5 for terrestrial animals for listed and non-listed species. The LOC for chronic effects for all animal taxa (listed and non-listed) is 1. Plant risks are handled in a similar manner, but with different toxicity thresholds (NOAEC/EC_{05} and EC_{25}, respectively) used in RQ calculation for listed and non-listed species and a LOC of 1 is used to interpret the RQ. When a given taxonomic RQ exceeds either the acute or chronic LOC for a taxonomic group, a concern for direct toxic effects is identified for that particular taxon. If RQs fall below the LOC for non-listed species, EPA makes a finding of no risk of concern. If the RQs fall below the LOC for listed species, EPA concludes that effects are not expected for that taxon and no further refinement is necessary to complete an Effects Determination for species within that taxon.

In this assessment EPA has presented both the comparison of RQs with both the non-listed and the listed LOCs. With the exception of plants, the non-listed species comparisons are intended to communicate risks to inform the findings under FIFRA. In the case of the listed species comparisons, the results are carried through to the Effects Determinations in **Section 2** where EPA uses the listed-species RQ:LOC comparisons to discriminate taxonomic groups requiring no further analyses from those where a species-specific risk assessment is needed to complete an Effects Determination.

1.6.1. Aquatic Organism Risk Characterization

The aquatic assessment used a Total Toxic Residues approach to evaluate risk from dicamba and its metabolite DCSA. An RQ was calculated for aquatic animals based on available data for freshwater fish [specifically rainbow trout (*Oncorhynchus mykiss*; MRID 40098001)]. The acute RQs for freshwater fish are <0.01 for fish exposed to either dicamba or DCSA metabolite following applications to either soybean or cotton (soybean and cotton parent dicamba EECs of 47.9 and 29.6 μg a.e./L and metabolite DCSA EECs of 2.36 and 3.08), respectively, divided by 28,000 μg a.e./L), and are more than two orders of magnitude below the Agency's acute LOC of 0.5. The results from the remaining acute aquatic animal studies were non-definitive (*i.e.*, no or little mortality was observed at the highest dose tested); therefore, EPA did not calculate acute RQs using these data.

In order to gain a better understanding of how the EECs for the maximum labeled dicamba application rate for cotton relate to the toxicity data currently available for aquatic animals, EPA compared the EECs to the toxicity endpoints using the conservative assumption that the highest concentrations tested in the acute aquatic animal studies represent endpoints (*e.g.*, acute: LC_{50}/EC_{50} = 100,000 μg a.e./L). This is conservative as it assumes that at that dose, 50% of the animals would not have survived, however in these studies there was either no mortality or substantially less than 50% mortality at this dose. In this exercise, the ratios of these non-definitive endpoints to the peak EECs for either dicamba or DCSA would all be more than two orders of magnitude below LOCs for estuarine/marine fish or aquatic invertebrates (freshwater and estuarine/marine).

Based on 1-in-10 year 60-day mean EECs of 42.9 and 24.6 μg a.e./L for parent dicamba, the chronic RQs for both the fathead minnow (NOAEC of 9,700 μg a.e./L) and sheepshead minnow (NOAEC 11,000 μg a.e./L) would be <0.01, which is well below the LOC of 1.0. However, acute toxicity data indicates rainbow trout are more sensitive than fathead and sheepshead minnows (LD50 of 28 mg a.e./L for trout compared to >56.4 for the fathead minnow and >180 mg a.e./L for the sheepshead minnow). Even with this increased sensitivity, the rainbow trout would have to be more than 270 times more sensitive than the fathead minnow on a chronic basis to result in an exceedance of the chronic LOC. Given that the acute data indicates that dicamba is only slightly more toxic to rainbow trout, the likelihood that dicamba is more than 2 orders of magnitude more sensitive on a chronic basis to rainbow trout compared to minnows is considered low. Similarly, chronic RQs are <0.01 (chronic LOC of 1.0) when comparing the chronic fish endpoints to the DCSA 1-in-10 year 60-day mean EECs of 2.66 and 2.21.

Based on 1-in-10-year 21-day mean EECs of 46.2 and 27.7 μg a.e./L, the chronic RQ for freshwater invertebrates is <0.01 based on the most sensitive aquatic invertebrate endpoints of 11,000 μg a.e./L for mysid shrimp and 42,000 μg a.e./L for daphnids. Similarly, chronic RQs would be <0.01, which is below the chronic LOC of 1.0, when comparing the chronic aquatic invertebrate endpoints to the DCSA 1-in-10-year 21-day mean EECs of 3.08 and 2.70.

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For aquatic plants the only RQs that exceed an Agency LOC (1.0 for both listed and non-listed aquatic plants) are for listed non-vascular aquatic plants following applications to either cotton or soybean (RQs range from <0.01 to 5.9; see **Table 1.9**). RQs for non-listed non-vascular aquatic plants and listed and non-listed vascular aquatic plants would all be below the LOC of 1.0. To date, there are no listed non-vascular aquatic plants within the 34 registered states for dicamba products on dicamba-tolerant crops. Based on the 1-in-10 year daily average EECs for the metabolite DCSA (3.1 and 2.4 µg a.e./L for cotton and soybean, respectively; **Table 1.4**), there would be no exceedances for either listed or non-listed species of vascular or non-vascular aquatic plants.

TABLE 1.9. RQs for Aquatic Plants and the Use of Dicamba on DT-Cotton and Soybean.

Use Sites	Listed/Non-Listed Taxa	1-in-10 Year Daily Mean dicamba EECs (µg a.e./L)	Risk Quotients	
			Vascular IC_{50} = 3,250 µg a.e./L NOAEC = 200 µg a.e./L	Non-vascular IC_{50} = 61 µg a.e./L NOAEC = 5 a.e./L
Cotton	Non-listed species	29.6	<0.01	0.49
	Listed species		0.15	**5.9**
Soybean	Non-listed species	47.9	0.01	0.79
	Listed species		0.24	**9.6**

Bolded numbers exceed the Agency LOC of '1'.
"a.e." = acid equivalent.

1.6.1.1. Potential off-field extent of risk to listed non-vascular aquatic plants from spray drift of dicamba residues

The edge of field concentration in the EPA-defined pond following spray drift of dicamba would be 0.46 µg a.e./L. This uses AgDRIFT[11] Tier I default settings (except for restricting droplet spectra to fine to medium/coarse, based on label requirements on nozzles that require even coarser droplet spectra than Tier I AgDRIFT settings can model) and the maximum ground application rate (0.5 lb a.e./A). As this concentration is an order of magnitude below the listed species non-vascular aquatic plant endpoint of 5 µg a.e./L, EPA does not anticipate risk to listed species of aquatic non-vascular plants from spray drift-alone.

1.6.2. Terrestrial Vertebrate Risk Characterization

1.6.2.1. Exposure to Parent Dicamba

1.6.2.1.1. On-field Dietary

EPA generated RQ values based on the upper bound EECs discussed in **Section 1.3** and toxicity values described in **Section 1.5**. For acute exposures to birds, dose-based RQs range from <0.01 to 2.1 based on upper-bound values and exceed the non-listed species LOC of 0.5 for small birds feeding on all dietary items except for fruits/pods/seeds and granivores and for medium birds feeding on exposed short grass and broadleaf plants (**Table 1.10**). EPA did not calculate acute dietary-based RQs for birds as the sub-acute dietary endpoint was non-definitive (LC_{50} > 10,000 mg a.e./kg-diet). As the maximum

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[11] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#AgDrift

dietary EECs presented in **Section 1.3** (260 mg a.e./kg-diet) are approximately two orders of magnitude below the dietary-based toxicity endpoint that resulted in no avian mortalities, EPA determines there are no acute-dietary risks of concern to birds. For chronic exposures for birds, dietary-based RQs based on reduced hatch and chick survival at 1390 mg a.e./kg-diet (NOAEC of 695 mg a.e./kg-diet), ranged from 0.02-0.35 and did not exceed the chronic LOC (1.0) for any dietary item. Therefore, EPA determined there were no chronic dietary-based risks of concern for birds.

Table 1.10. Acute and Chronic RQ values for Birds, Reptiles, and Terrestrial-Phase Amphibians Exposed to Dicamba Residues from the Use of Dicamba Products on Dicamba-Tolerant crops (T-REX v. 1.5.2, Upper Bound Kenaga)

| Food Type | Acute Dose-Based RQ LD$_{50}$ = 188 mg a.e./kg-bw | | | Acute Dietary-Based RQ LC$_{50}$ >10,000 mg a.e./kg-diet | Chronic Dietary RQ NOAEC = 695 mg a.e./kg-diet |
	Small (20 g)	Medium (100 g)	Large (1000 g)		
DT-Cotton/Soy (4 x 0.5 lb a.e./A)					
Herbivores/Insectivores					
Short grass	**2.1**	**0.93**	*0.29*	NC	0.35
Tall grass	**0.95**	*0.43*	*0.13*	NC	0.16
Broadleaf plants	**1.2**	**0.52**	*0.17*	NC	0.20
Fruits/pods/seeds	*0.13*	0.06	0.02	NC	0.02
Arthropods	**0.81**	*0.36*	*0.12*	NC	0.14
Granivores					
Seeds[1]	0.03	0.01	<0.01	N/A	N/A

Bolded values exceed the LOC for acute risk to non-listed species of 0.5 or the chronic risk LOC of 1.0. ***Bold italicized*** numbers exceed the acute risk LOC for listed species (RQ > 0.1). The endpoints listed in the table are the endpoint used to calculate the RQ.
[1] Seeds presented separately for dose – based RQs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

For mammals, none of the acute RQs from exposure to dicamba exceed any of the Agency's LOCs (acute dose-based RQs range from <0.01 to 0.04 for dicamba; **Table 1.11**). Additionally, none of the dietary-based chronic RQs exceed the Agency's LOCs for chronic risk (chronic dietary-based RQs range from 0.01 to 0.09 for dicamba). Chronic dose-based RQs also do not exceed the Agency LOC for chronic risk from dicamba (RQs range from <0.01 to 0.79; **Table 1.12**).

Table 1.11. Acute RQ values for Mammals Exposed to Dicamba Residues from the Use of Dicamba Products on Dicamba-Tolerant crops (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Acute Dose-Based RQ LD_{50} = 2740 mg a.e./kg-bw		
	Small (15 g)	Medium (35 g)	Large (1000 g)
Herbivores/Insectivores			
Short grass	0.04	0.03	0.02
Tall grass	0.02	0.02	0.01
Broadleaf plants	0.02	0.02	0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.02	0.01	0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01

The LOC for acute risk to non-listed species is 0.5. The endpoints listed in the table are the endpoint used to calculate the RQ.

Table 1.12. Acute and Chronic RQ values for Mammals Exposed to Dicamba Residues from the Use of Dicamba Products on Dicamba-Tolerant crops (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Chronic Dose-Based RQ NOAEL = 136 mg a.e./kg-bw			Chronic Dietary-Based RQ NOAEC = 2720 mg a.e./kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
DT-Cotton/Soy (4 x 0.5 lb a.e./A)				
Herbivores/Insectivores				
Short grass	0.79	0.67	0.36	0.09
Tall grass	0.36	0.31	0.16	0.04
Broadleaf plants	0.44	0.38	0.20	0.05
Fruits/pods/seeds	0.05	0.04	0.02	0.01
Arthropods	0.31	0.26	0.14	0.04
Granivores				
Seeds[1]	0.01	0.01	<0.01	N/A

chronic LOC is 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ. Chronic diet concentration NOAEC is based upon NOAEL and the daily diet consumption of laboratory rat, estimated in TREX.

1.6.2.2. On-field Risk Assessment for Inhalation Exposures

EPA used the Screening Tool for Inhalation Risk (STIR v.1.0) to assess the potential for risk to birds and mammals through inhalation exposure. The exposure pathways that are assessed by this tool include both droplet inhalation and vapor-phase inhalation. STIR is intended to determine if exposure is likely and not whether the potential for risk exists based on a chemical's maximum application rate, molecular weight and vapor pressure and the available mammalian acute oral and inhalation toxicity endpoints and avian acute oral endpoint (an adjusted avian inhalation toxicity endpoint of >2.0 mg ae/L was estimated from the mammalian toxicity data). It is important to note that the mammalian inhalation endpoint is non-definitive (>5.3 mg ae/L). If STIR predicts that exposure is likely, additional inhalation data may be necessary to adequately assess risk due to the inhalation exposure pathway. Based on STIR,

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inhalation is not considered likely to be a significant route of exposure for birds and mammals from vapor exposure or spray droplet inhalation. Exposure estimates are more than two orders of magnitude below the estimated avian inhalation endpoint and more than four orders of magnitude below the mammalian inhalation endpoint (**Table 1.13**). Given that the mammalian inhalation endpoint is non-definitive, based on a lack of mortality, these estimates are highly conservative. See **Appendix M** for STIR inputs and outputs.

Table 1.13. Estimated Vapor-Dose and Spray Inhalation Dose Exposures and Resulting Exposure:Toxicity Ratios Following Dicamba Application (0.5 lb a.e./A)

Assessed Taxa	Maximum 1-hr Vapor Inhalation Dose (mg/kg)	Ratio of Vapor Dose to Inhalation LD_{50} [> 5.3 mg ae/L (mammals) > 2.0 mg ae/L (birds; estimated)]	Maximum Post-treatment Spray Inhalation Dose (mg/kg)	Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}
Small (20 g) bird	0.051	< 0.025	0.053	<0.01
Small (15 g) mammal	0.064	<0.020	0.064	<0.01

1.6.2.3. Spatial Extent of Off-field Risks from Spray Drift of Dicamba Residues

The analysis above indicated no on-field acute or chronic risk to mammals or chronic risk to birds from exposure to dicamba residues in dietary items. The maximum acute RQ observed in the above analysis for dicamba exposures on likely dietary items in DT-soybean and cotton fields following spray applications of dicamba products was 2.1 for small birds feeding on short grass. Therefore, for off-field exposures from spray drift, the necessary drift fraction below which dicamba residues would no longer exceed the non-listed species LOC is 0.24 (0.5/2.1) and would be 0.048 to no longer exceed the listed species LOC of 0.1 (0.1/2.1). EPA used AgDRIFT (v2.1.1) to model off-field spray drift, using Tier I default settings (except for restricting droplet spectra to fine to medium/coarse, based on label requirements on nozzles that require even coarser droplet spectra than Tier I AgDRIFT settings allow). The spray drift of dicamba residues fall below these fractions at 3.3 and 13 feet off the treated field, for non-listed and listed bird species respectively. Given that the labels require nozzles to restrict the droplet spectra significantly more than AgDRIFT Tier I modeling allows, and that the labels include a requirement of an in-field downwind 240 foot setback, it can be concluded that acute risks to birds are restricted to the field.

1.6.2.4. DCSA Chronic Effects Assessment for Terrestrial Organisms

1.6.2.4.1. DCSA Risk Characterization Following Applications to Soybeans

No data are available for the chronic effects of DCSA to birds. In the absence of these data, EPA conservatively assumed that the ratio of parent dicamba to DCSA toxicity (17x differential) from the mammalian toxicity data could be applied to the chronic effects endpoint for birds, resulting in a chronic avian endpoint of 40.9 mg/kg-bw. However, the DCSA chronic endpoint for mammals is based on effects to pups who were continually exposed in utero in the study. Therefore, it is conservative to assume that this toxicity differential in mammals for parent dicamba and DCSA would be equivalent for

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chicks who would not be exposed to DCSA residues during their gestation in the egg (beyond initial maternal transfer into the egg during egg development).

Using the empirical dataset for DCSA residues in DT-soybean crops (as described above), the maximum residues in soybean forage and hay tissue were 61.1 mg/kg-diet and in seeds were 0.440 mg/kg-diet. EPA assumed residues in arthropods (as a dietary item for birds and mammals consuming insects that have consumed soybean tissues with DCSA residues) to follow the Kenaga nomogram (Hoerger and Kenaga, 1972; Fletcher *et al.*, 1994) relationship between broadleaf plants (*i.e.* soybean tissue) and arthropods for spray applications and therefore were considered to contain 42.5 mg/kg-diet. This is likely conservative, given that the estimated residues from the nomogram are for external (and internal) residues in food items following a spray application while the actual exposures would be only internal residue concentrations in the plant. Using this empirical data for the exposure values to calculate RQs results in exceedances of the chronic LOC of 1.0 for all size classes of mammals consuming either soybean forage/hay tissue or consuming insects that had previously consumed soybean tissues contaminated with DCSA residues (RQs range from **1.1—3.3, Table 1.14**). Chronic exceedances would similarly exist for small birds consuming either forage/hay tissue or insects that had fed on DT-soybean tissues, (RQs range from **1.2—1.7, Table 1.15**) and medium birds feeding on forage/hay tissue (RQ = **1.0**) but no exceedances occurred for any size mammalian or avian granivore consuming soybean grain (max granivore RQ of < 0.01). As noted above, any potential risks from exposure of terrestrial vertebrates to DCSA residues are confined to DT-soybean plants on the treated field (as off-site plants as well as surviving weed species on the field would not be anticipated to convert dicamba residues to DCSA in substantial quantities given that this conversion is seen primarily in DT-crops).

Table 1.14. Dose-based exposure, body-weight adjusted chronic endpoints and risk quotients for mammals consuming DT-soybean tissues containing DCSA residues (maximum 61.1 mg/kg in forage/hay, 0.44 mg/kg in seeds) or consuming arthropods that had fed on DT-soybean tissues (assumed to contain 42.5 mg/kg DCSA). Bold RQ values exceed the chronic LOC of 1.0.

Size Class (g)	Dietary Item	Food Intake (k-diet/d)	Dose-based EEC (mg/kg-bw)	Adjusted NOAEL (mg/kg-bw)	RQ
Small (15g)	Forage/Hay	0.0143	58.25	6.2	**3.3**
	Seed	0.00318	0.09	6.2	<0.01
	Arthropod	0.0143	40.52	6.2	**2.3**
Medium (35g)	Forage/Hay	0.0231	40.33	14.2	**2.8**
	Seed	0.00513	0.06	14.2	<0.01
	Arthropod	0.0231	28.05	14.2	**2.0**
Large (1000g)	Forage/Hay	0.153	9.35	17.6	**1.5**
	Seed	0.0340	0.01	17.6	<0.01
	Arthropod	0.153	6.50	17.6	**1.1**

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Table 1.15. Dose-based exposure and risk quotients for birds consuming DT-soybean tissues containing DCSA residues (chronic endpoint assumes a 17x differential in toxicity between parent dicamba and DCSA for birds). Bold RQ values exceed the chronic LOC of 1.0.

Size Class (g)	Dietary Item	Food Intake (k-diet/d)	Dose-based EEC (mg/kg-bw)	NOAEC (mg/kg-bw)	RQ
Small (20g)	Forage/Hay	0.0228	69.65	40.9	**1.7**
	Seed	0.0051	0.11	40.9	<0.01
	Arthropod	0.0228	48.45	40.9	**1.2**
Medium (100g)	Forage/Hay	0.0649	39.65	40.9	**1.0**
	Seed	0.0144	0.06	40.9	<0.01
	Arthropod	0.0649	27.58	40.9	0.7
Large (1000g)	Forage/Hay	0.291	17.78	40.9	0.4
	Seed	0.065	0.03	40.9	<0.01
	Arthropod	0.291	12.37	40.9	0.3

While this assessment used the comparison of the maximum residues detected with the chronic mammalian endpoint, there is some uncertainty due to the limited temporal sampling of DCSA residues in DT-soybean tissues (forage from days 7-10, hay from days 13-15 and seeds from days 73-98). Without residue measurements closer to the time of application, the rate at which dicamba is converting to the metabolite and whether potential upper bound residues are captured by the empirical DCSA data that is available is not completely known. Plant metabolism studies that track DCSA residues over time in all parts of DT-soybean plants following post-emergent applications would decrease this uncertainty. In the absence of such studies, EPA used the best available data and the maximum measured residues to evaluate the chronic exposure. By using the best available information for DCSA residues and the maximum residues measured in soybean tissue (including the conservative relationship for arthropod diet described above), the observation that DCSA residues in soybean tissue increased only slightly between forage (day 7-10) and hay (day 13-15) and that little dicamba was left to convert to DCSA at this time **(Appendix N)** and the assumption that the animal is only eating diet obtained from the treated field, EPA's assessment is conservative.

As noted above, EPA calculated these RQs based on the female lactation dose NOAEL endpoint of 8 mg/kg/d from the DCSA 2-generation study where reductions of up to 9% pup body weight were observed 2-3 weeks post birth at the next highest dose (78 mg/kg/d), which is above the maximum empirical residues. Further, if the $BMDL_5$ (the lower 95% confidence level on the estimated benchmark dose to result in a 5% body weight change in pups from background levels) of 34.9 mg/kg/d calculated by HED (USEPA, 2016c) for DCSA was used in place of the NOAEL, then the maximum residues from the empirical data in soybean hay would be below the threshold dose for all size classes of mammals feeding on soybean plant tissue or soybean-consuming arthropods (RQs would range from 0.35—0.76 for mammals feeding on tolerant soybean tissues and 0.24—0.53 for mammals feeding on arthropods having consumed soybean tissues, which would be below the chronic LOC of 1.0).

Overall, EPA concludes that there is potential for chronic risk to on-field mammals and birds from exposure to DCSA residues in common dietary items following dicamba applications to dicamba-tolerant soybeans. Further refinements to complete Effects Determinations within these taxa are described in **Section 2**.

1.6.2.4.2. DCSA Risk Characterization Following Applications to Cotton

Empirical data for DCSA are available from magnitude of residue studies reviewed by HED (MRIDs 48728701 and 48728703) for dicamba pre- and post-emergent applications on DT-cotton (4 applications at a total of 2.0 lbs a.e./A, 4 different treatment groups with differing timing of applications). These data show dicamba and DCSA residues in undelinted cotton seed and gin byproducts (residual cotton plant parts) had maximum residues of 23.6 mg/kg-diet dicamba and 6.29 mg/kg-diet DCSA at 6-7 days following the last application. Using the maximum DCSA residues in gin byproducts (6.29 mg/kg-diet) or undelinted cotton seed (0.27 mg/kg-diet) would not result in an exceedance of the chronic LOC of 1.0 for any size class of mammal or bird (RQs would range from <0.01—0.34; **Tables 1.16 and 1.17**). EPA assumed residues in arthropods that consume DCSA residues from DT-cotton (as a dietary item for birds and mammals)) follow the Kenaga nomogram relationship between broadleaf plants and arthropods. Therefore, arthropods were considered to contain 4.4 mg/kg DCSA which also would not result in any exceedances compared to the chronic LOC of 1.0 (RQ's range from 0.11—0.24).

While this assessment used the comparison of the maximum residues detected with the chronic mammalian endpoint, there is some uncertainty due to the limited temporal sampling of DCSA residues in DT-cotton tissues (only measured at one time point) and therefore understanding formation/decline rates is not possible (to better understand potential maximum residues). Plant metabolism studies that track DCSA residues over time in all parts of DT-cotton plants following post-emergent applications would decrease this uncertainty. In the absence of this, EPA has used the best available data and the maximum measured residues to evaluate the chronic exposure. This risk estimation uses the NOAEC endpoint of 8 mg/kg/d. If the $BMDL_5$ of 34.9 mg/kg/d for DCSA effects to mammals calculated by HED were used instead, then the maximum chronic RQ would be 0.08. Given that the maximum measured DCSA residues are not close to the NOAEC threshold endpoint (max RQ of 0.34) and the $BMDL_5$ indicates that biological effects may not be expected even if residues were an order of magnitude higher than indicated by the maximum measured residues, the lack of a plant metabolism study tracking DCSA residues throughout the DT-cotton plant is not considered an uncertainty that significantly alters the risk characterization conclusions.

Table 1.16. Dose-based exposure, body-weight adjusted chronic endpoints and risk quotients for mammals consuming DT-cotton tissues containing DCSA residues (max empirical values of 6.29 mg/kg in broadleaf plant tissue (gin byproducts), 0.27 mg/kg in seeds)

Size Class (g)	Dietary Item	Food Intake (k-diet/d)	Dose-based EEC (mg/kg-bw)	Adjusted NOAEL (mg/kg-bw)	RQ
Small (15g)	Broadleaf plant	0.0143	58.25	17.58	0.34
	Seed	0.00318	0.09	17.58	<0.01
	Arthropod	0.0143	4.19	17.58	0.24
Medium (35g)	Broadleaf plant	0.0231	40.33	14.23	0.29
	Seed	0.00513	0.06	14.23	<0.01
	Arthropod	0.0231	2.90	14.23	0.20
Large (1000g)	Broadleaf plant	0.153	9.35	6.15	0.16
	Seed	0.0340	0.01	6.15	<0.01
	Arthropod	0.153	0.67	6.15	0.11

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Table 1.17. Dose-based exposure and risk quotients for birds consuming DT-cotton tissues containing DCSA residues (chronic endpoint assumes a 17x differential in toxicity between parent dicamba and DCSA to birds).

Size Class (g)	Dietary Item	Food Intake (k-diet/d)	Dose-based EEC (mg/kg-bw)	NOAEC (mg/kg-bw)	RQ
Small (20g)	Broadleaf plant	0.0228	7.17	40.88	0.18
	Seed	0.0051	0.07	40.88	<0.01
	Arthropod	0.0228	5.02	40.88	0.12
Medium (100g)	Broadleaf plant	0.0649	4.08	40.88	0.07
	Seed	0.0144	0.04	40.88	<0.01
	Arthropod	0.0649	2.86	40.88	0.14
Large (1000g)	Broadleaf plant	0.291	1.83	40.88	0.04
	Seed	0.065	0.02	40.88	<0.01
	Arthropod	0.291	1.28	40.88	0.03

Based on the above assessment, EPA finds that the uses of dicamba products on dicamba-tolerant cotton plants results in on-field DCSA exposures that are not at levels to cause a chronic risk of concern.

1.6.3. Honeybee Risk Assessment

The uses being assessed for dicamba products on dicamba-tolerant crops are on soybean, which produces pollen and nectar attractive to bee species, and on cotton, which only produces nectar attractive to bee species (USDA, 2018). The labels prohibit application to soybeans after June 30th or the R1 stage, whichever comes first), which likely decreases exposure to bees on soybean fields. The labels also prohibit applications to cotton after July 30th. Given that cotton is an indeterminate blooming crop and that this date is later in the summer, it is uncertain the degree to which this would decrease exposure of foraging bees on cotton fields. Bees may also consume both pollen and nectar from dicamba-exposed flowering weed species. The pollen and nectar may contain dicamba residues either from direct spray or resulting from systemic uptake of dicamba residues. Bees (both Apis and non-Apis) may be exposed on or off-the field to direct sprays of dicamba to DT-cotton or soybean plants or, without the mandatory control measures on the label to address for spray drift/volatility, exposure off the field and subsequent deposition on attractive floral resources may result.

1.6.3.1. Bee Tier I Exposure Estimates

EPA estimated contact and dietary exposure separately using different approaches specific to different application methods. The Bee-REX model (Version 1.0) calculates default (*i.e.*, high end, yet reasonably conservative) EECs for contact and dietary routes of exposure for foliar, soil, and seed treatment applications. **Appendix M** for a sample output from Bee-REX for dicamba. Additional information on bee-related exposure estimates, and the calculation of risk estimates in Bee-Rex can be found in the *Guidance for Assessing Pesticide Risks to Bees* (USEPA *et al.*, 2014).

1.6.3.2. Tier I Risk Estimation (Contact Exposure)

1.6.3.2.1. On-Field Risk

Since bees are potentially exposed to dicamba through use on DT-soybean and cotton plants and both on and off the treated field, the next step in the risk assessment process is to conduct a Tier 1 risk assessment. By design, the Tier 1 assessment begins with (high-end) model-generated (foliar and soil treatments) or default (seed treatments) estimates of exposure via contact and oral routes. For contact exposure, only the adult (forager and drones) life stage is considered since this is the relevant caste of honeybees (*i.e.*, since other bees are in-hive, the presumption is that they would not be subject to contact exposure). Furthermore, toxicity testing protocols have only been developed for acute exposures. Effects are defined by laboratory exposures to groups of individual bees (which serve as surrogates for solitary non-*Apis* bees and individual social non-*Apis* bees).

On the basis of acute contact exposure to adult honeybees, RQs, based on a non-definitive honeybee endpoint of >90.7 μg a.e./bee would be more than an order of magnitude below the acute LOCs (0.4) and therefore EPA finds no acute risk of concern to non-listed bees from the use of DT-crop dicamba products (**Table 1.18**).

Table 1.18. Default Tier I Adult, Acute Contact Risk Quotients for Honeybees Foraging on DT-Crops from BEE-REX (v1.0).

Use Pattern	Bee Attractiveness	Max. Single Application Rate	Dose (μg a.i./bee per 1 lb a.i./A)	Dicamba Contact Dose (μg a.i./bee)	Acute RQ[1]
Soybean	Y (nectar & pollen)	0.5 lb a.e./A	2.7	1.35	<0.01
Cotton	Y (nectar only)	0.5 lb a.e./A	2.7	1.35	<0.01

[1] Based on a 48-h acute contact LD_{50} of > 90.7 μg a.i./bee for dicamba (MRID 00036935). Acute LOC = 0.4.

1.6.3.3. Tier I Risk Estimation (Oral Exposure)

1.6.3.3.1. On-Field Risk

For oral exposure, the Tier I assessment considers the caste of bees with the greatest oral exposure (foraging adults). If risks are identified, then other factors can be considered for refining the Tier I risk estimates. These factors include other castes of bees and any available information on empirical residues in pollen and nectar applicable to the crops of interest. As noted in **Section 1.4**, a screen of newly submitted acute oral data for adult and larval honeybees found that acute effects were not reported in these studies and therefore, EPA finds that there are no acute risks of concern for adult and larval bees. Additionally, EPA also finds no chronic risks of concern for adult bees (Max chronic RQ of 0.85, which is below the chronic LOC of 1.0). EPA finds that there is chronic oral risk of concern for larval bees as the RQ (1.3) is above the chronic LOC of 1.0 (**Table 1.19**). Further refinement to complete Effects Determinations for terrestrial arthropods including bees are provided in **Section 2**.

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Table 1.19. Tier 1 (Default) Oral Risk Quotients for Adult Nectar Forager and Larval Worker Honeybees from BeeREX (ver. 1.0)

Use Pattern	Max. Single Appl. Rate	Bee Caste/Task	Unit Dose (μg a.i./bee per 1 lb a.i./A)	Oral Dose (μg a.i./bee)	Acute Oral RQ[1,]	Chronic Oral RQ[2,3]
Soybean	0.5	Adult nectar forager	32	16	NC	0.85
		Larval worker	14	6.8	NC	**1.3**
Cotton[4]	0.5	Adult nectar forager	32	16	NC	0.85
		Larval worker	13	6.6	NC	**1.3**

[1]Acute oral RQs were not calculated (NC) due to lack of reviewed data.
[2] **Bolded** RQ value exceeds (or potentially exceeds) the acute risk LOC of 0.4 or chronic LOC of 1.0.
[3] Based on a 10-d chronic NOAEL of 19 μg a.i./bee/d for adults (MRID 50784603) and a 22-d chronic NOAEL of 5.1 μg a.i./bee/d for larvae (MRID 50784602).
[4] Although the application rate is the same, exposures in cotton are very slightly smaller due to the lack of attractive pollen. However, pollen makes up a very small proportion of the diet for the castes with greatest exposure (adult-stage nectar foragers and Day 5 larval-stage worker bees).

The BeeREX calculated upper bound residue estimates (6.6 μg a.e./larvae) are below the larval LOAEC value (10 μg a.e./larvae) that was associated with 29% increased pupal mortality and 28% decreased adult emergence, relative to control larvae. No Tier II bee data are available to refine these risk estimates. For oral exposure, some refinement of Tier 1 risk estimates is possible based on consideration of different bee castes and tasks (each differing in their nectar and pollen consumption rates) and consideration of measured values of pesticide residues in pollen and nectar. For adult bees, chronic RQs do not exceed (RQ ≤ 0.85) the chronic LOC for any honeybee caste. For larval bees, the chronic RQs exceed the chronic LOC (1.0) for both larval-stage drones (RQ of 1.4) and day 5 worker larvae (RQ of 1.3). The conclusion of on-field risk for larval bees is based on the conservative assumption that 100% of the larvae's diet comes from exposed nectar and pollen. Given the relatively low level of exceedances, EPA considered the potential effect that dilution of residues from other (untreated) sources may have on the risk estimates. If more than 25% of the larvae's diet comes from untreated sources, then it is likely that exposures would be below the larval bee NOAEC threshold. Given that the labels restrict applications to soybeans to before June 30th or the R1 stage, whichever comes first, it is likely that any risks to larval bees from exposed pollen and nectar do not persist for long periods of time (and relatively fewer soybean flowers may be in bloom at this time, further decreasing potential risks). These reductions likely prevent dicamba applications during periods of full soybean flower and therefore reduce the opportunity for pollinator exposure. This characterization of honeybee castes and resources is specific to the species, any further risk characterization steps to complete an Effects Determination for a listed bee species is included in **Section 2**.

The labels restrict applications to cotton to before July 30th. Given that cotton is an indeterminate blooming crop, the degree to which this restriction may reduce the temporal extent of risk to larval bees is uncertain.

The use of honeybees as a surrogate for other bee pollinators has limitations. Data on individual honeybees provides information appropriate for solitary bee species. Honeybee colony-level data can provide relevant information on the potential effects of a pesticide on other social bees with similar social and colony organization. Previous analysis (USEPA *et al.*, 2012) of food consumption rates (of

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pollen and nectar) for individuals of several species of bees suggests that honeybees are similar or protective of other species. Therefore, honeybees represent an appropriate surrogate for assessing individual level risks to other species of bees.

1.6.3.3.2. Off-field Risk

In addition to bees foraging on the treated field, bees may also be foraging in fields adjacent to the treated fields. The analysis above indicated potential for chronic risk to bees on the treated field. The maximum chronic RQ observed in the above analysis was 1.3 for larval-stage bees. Therefore, for off-field exposures, not taking into the mandatory control measures to address spray drift, the necessary drift fraction below which dicamba residues would no longer exceed the chronic LOC of 1.0 is 0.77 (1.0/1.3) for larval bees. EPA used the AgDRIFT Tier I model with default settings (except that the droplet spectra was restricted to "fine to medium/coarse", and the label requires nozzles that are even more restrictive for coarse droplet spectra than Tier I AgDRIFT settings allow). Using these settings, the spray drift of dicamba residues fall below this drift fraction by 3.3 feet off the treated field. Given that the labels require coarser droplet spectra than AgDRIFT Tier I modeling allows and that these labels include a mandatory in-field downwind 240-foot spray drift setback, EPA concludes that chronic risks to bees from exposure to dicamba following dicamba applications to dicamba-tolerant crops are restricted to the field.

1.6.4. Other Terrestrial Invertebrates

1.6.4.1. Use of Honeybee Toxicity Data as a Surrogate for Other Terrestrial Invertebrate Species

The application of honeybee effects data for this evaluation of impact to other terrestrial invertebrate species (*e.g.* beetles, butterflies, etc.) is based on the surrogate species approach, whereby the effects endpoints established for honeybees are used to represent the sensitivity of other invertebrate species. To use this data to evaluate risks to other terrestrial invertebrates, EPA converted the dose-based endpoints to concentration-based endpoints that it then compared to potential exposures based on T-REX modeling for other terrestrial invertebrates. As the acute data for honeybees were non-definitive (*i.e.* no mortalities were observed at the highest tested doses), EPA considered the much more sensitive chronic honeybee endpoints for this comparison. The most sensitive adult honeybee NOAEL was from MRID 50784603 and was 19 µg a.e./bee, which was equivalent to a NOAEC of 590 mg a.e./kg-die, based on significant impacts to food consumption (24% inhibition, relative to controls) at 33 µg ai/bee (1179 mg ai/kg-diet). The most sensitive larval honeybee NOAEL was from MRID 50784602 and was 5.1 µg ai/larva/day (equivalent to a NOAEC of 129.7 mg ai/kg-diet), based on significant impacts to pupal mortality (29% inhibition, relative to controls) and adult emergence (28% inhibition, relative to controls) at 10 µg ai/bee (which was equivalent to 260.9 mg ai/kg-diet).

1.6.4.2. Screening Estimations of On- and Off-Field Exposure for terrestrial invertebrates

EPA conducted screening estimations of terrestrial invertebrate exposure using two methods. The first method involves a direct comparison of insect residues in exposed animals (exposure originating from contact with the pesticide incidentally and by impingement of spray as well as any consumption of

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contaminated diet). EPA compared this estimate to the tested honeybee effects endpoints expressed in terms of mass of pesticide /mass of exposed insect. The second route of exposure is dietary exposure expressed as a concentration of pesticide in vegetation receiving pesticide application. EPA compared this second exposure estimation to the effects endpoint expressed on a mass of pesticide/mass of diet basis. The exposure estimates for any terrestrial invertebrate warranting more refined estimation methods (where screening estimates and available biological data for a species indicate a potential concern) are included in the individual species effects determinations in **Section 2**.

1.6.4.2.1. On-Field

EPA estimated on-field screening exposure for terrestrial invertebrates through the application of the TREX model (v 1.5.2), as described in **Section 1.4** , which estimates a pesticide concentration in insects following exposure to direct pesticide spray and any residues ingested from diet also receiving direct spray. EPA estimated residues using two 0.5 lbs a.i./A pre-emergent applications, with two 0.5 lbs a.i./A post-emergent applications, with seven-day retreatment intervals between each. Dietary EECs were based on the TREX predictions for the most conservative vegetation (**Section 1.4** ; short grass), yielding a diet concentration EEC of 250 mg/kg-diet, and whole terrestrial arthropod dose estimates were based on TREX predicted EECs for terrestrial arthropods yielding an estimated dose 96 mg/kg-bw.

1.6.4.2.2. Off-field

For any terrestrial invertebrate results where LOCs were exceeded, EPA used the model AgDRIFT to determine the distance off-field where the fraction of spray drift deposition would result in risk quotients below the relevant LOC. EPA used the following parameters in the Tier I Ground (Agricultural) component of the model: High Boom, 90th percentile, ASAE fine to Medium/Coarse. The high boom, upper bound (90th percentile) distributions of residues is conservative because label requires a low boom height, and the droplet spectra assumption is conservative because the label requires coarser droplets than a medium/coarse standard.

1.6.4.3. Risk Characterization for On-Field Terrestrial Invertebrates

Based on a comparison of endpoints, the larval honeybee data yields the most sensitive estimates of effects endpoints. EPA selected this as a conservative basis to derive risk quotients for the risk assessment and employed both methods (calculating insect residue estimates and also dietary residues in vegetation) for deriving an effect RQ. EPA then compared these RQ's were with a corresponding LOC to determine whether there were potential on-field risk concerns.

On-Field Risk Conclusions Based Exposure Calculated as Insect Residue Estimates

NOAEL-based method for RQ
Tox endpoint= (5.1 ug a.e./bee)(bee/0.128 g{*default bee weight*}) = 39.8 ug/g = 39.8 mg/kg
Exposure estimate = 96.0 mg a.e./kg
RQ = (96.0 mg a.e./kg)/(39.8 mg a.e./kg) = 2.4
LOC for comparison = 1.0
Conclusion: 2.4 > 1.0 = potential risk concern

On-Field Risk Conclusions Based on Exposure Calculated from Vegetation Residue Estimates

NOAEC-based method for RQ
Tox endpoint= 129.7 mg ai/kg-diet
Exposure estimate = 250 mg a.e./kg-diet
RQ = (250 mg a.e./kg-diet)/(129.7 mg a.e./kg-diet) = 1.9
LOC for comparison = 1.0
Conclusion: 1.9 > 1.0 = potential risk concern

Conclusions for On-Field Risk Characterization for Terrestrial Invertebrates

Use of the most sensitive life stage (larval) honeybee data results in potential risk concerns under all scenarios modeled for non-bee terrestrial invertebrates. Further refinements to complete Effects Determination for this taxon are included in Section 2.

1.6.4.4. Risk Characterization for Off-Field Terrestrial Invertebrates

For this evaluation, EPA calculated a target fraction of the field application rate that is necessary to drop below the LOC for each on-field risk estimation above. Then, EPA solved the equation for distance off-field at which point the deposition from spray drift would equal the established target fraction of the field application rate. The RQs calculated above were 2.4 for exposures calculated as insect residue estimates and 1.9 for exposures calculated as vegetation residue estimates. Based on the chronic LOC of 1.0, the target spray drift fractions of the field application rate are therefore 0.42 (fraction = 1/2.4) and 0.53 (fraction = 1/1.9) for each method.

Using AgDRIFT Tier I default settings (except for restricting droplet spectra to the range from fine to medium/coarse, based on label requirements on nozzles that require even coarser droplet spectra than Tier I AgDRIFT settings allow), the spray drift of dicamba residues fall below these fractions by <3 feet off the treated field. Given that the label allowed nozzles restrict droplet spectra significantly more than AgDRIFT Tier I modeling allows and that the labels require a wind-directional 240 foot setback at the time of application, EPA concluded that any potential risks of concern to terrestrial invertebrates from exposure to dicamba following dicamba applications to dicamba-tolerant crops are restricted to the treated field.

1.7. Terrestrial Plant Risk Assessment

1.7.1. Summary of the Risk Assessment Approach for Dicamba

EPA considers reduction in growth, survival and reproduction as regulatory endpoints. In this assessment, EPA evaluated a large number of studies from the registrants, academia, and weed scientists to determine the appropriate in-field setbacks to address the potential the potential for off-field effect to non-target organisms.

EPA considered endpoints derived from several types of greenhouse- and field-based studies that exposed plants to multiple concentrations following a direct spray of dicamba product or through a vapor phase dicamba exposure (**Appendix C**). Using these studies, EPA selected a suite of endpoints to conduct the non-target plant risk assessment. In addition to typical measurement endpoints of height

and weight, EPA also considered additional measurement specific to plant reproduction (yield), and the measurement of visual signs of injury. Visual signs of injury (VSI) is the measure of abnormal growth as a result of dicamba disrupting normal cell function, cell growth and tissue development. VSI is a standard measure of dicamba effect on plants used in academic and registrant direct spray toxicity studies, in field studies evaluating off-field movement, and by states investigating reports of dicamba damage. For many of these sources of information, VSI is the only measure of effect that is observed. Thus, the use of the measurement of VSI allows EPA to compare dicamba effects across a wider variety of data sources than afforded by the use of height, weight, survival or yield.

For the assessment of potential risks to plants, EPA selected the measurement of VSI as an endpoint for two reasons: 1) to allow EPA to utilize the broadest range of available field effects data across a variety geographic areas, meteorological conditions, and agronomic practices; and 2) to give meaningful weight to the observations of visual symptomology that form the majority of incident-reported plant observations associated with dicamba exposure. EPA recognized that the use of VSI must be placed in the context of traditional regulatory endpoints of survival, growth and reproduction.

To help inform the regulatory endpoint, EPA used the measurement of VSI to determine at what percentage of VSI there is a corresponding 5% reduction in plant height. EPA evaluated the association of the measurements of VSI, height, and yield responses to dicamba under both greenhouse and field conditions in studies submitted to EPA by registrants and academics. EPA found that the levels of VSI that correspond to a 5% reduction in height or a 5% reduction in yield are variable across the available data and are likely dependent upon soybean variety and a variety of field and agronomic factors. Ultimately, EPA determined that 10% VSI is a sensitive endpoint which is expected to be protective against 5% reductions in plant height and yield with a high degree of certainty. The 10% VSI is a conservative protective threshold for the most sensitive of plant species. Based on the available toxicity data, 95% of observed cases of VSI at exposures causing a 5% height or yield reduction were greater than 10%. Because other factors are likely important to the ultimate plant growth and yield relationship to observations of VSI, the (10% VSI) alone is not predictive of significant yield loss or growth impairment in non-target plants.

EPA used a set of field studies, identified as Off-Field Movement (OFM) studies, to understand potential distances from the site of application where plant effects were no longer likely to occur (**Section 1.7.2; Appendix C**). Plant height was included as a measurement in several OFM studies, however all OFM studies observed the response of plants as percent of VSI in relation to the distance from the treated field. Thereby, using the measurement of VSI to estimate the distance to effect allows for a more complete use of the available OFM studies, increasing the geographic, temporal, climatic, and soybean varieties tested. To make use of the most comprehensive dataset of OFM studies, EPA conducted a probabilistic approach to define off field distances for spray drift + volatility exposure, and volatility exposure alone. These distances to effect were used to establish distances at various levels of protection (e.g., 95th percentile) which were used to determine the protectiveness of required in-field setbacks on the labels.

The following sections of this terrestrial plant risk assessment describe the data, endpoint selection process, and utilization of the endpoints in defining off-field distances to plant effects in greater detail.

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1.7.2. EPA's use of Plant Endpoints in Risk Assessment

To assess the effects on organisms exposed to a chemical stressor, EPA evaluates the available ecotoxicological literature to determine effects directly relating to an organism's fitness in the environment (*i.e.* effects reducing an organisms' survival, reproductive capacity and/or physiological growth; USEPA, 2004). Terrestrial plant reproduction (e.g., yield) is not easily measured under greenhouse conditions, therefore EPA typically relies upon plant measurement endpoints of height and weight as well as plant survival which are commonly observed in greenhouse studies. Plant height and weight endpoints address the ability of plants to compete for resources, thereby enhancing survival, and achieving sufficient growth to obtain adequate resources for the increased energetic needs of reproduction.

As mentioned above, EPA typically uses measurements of growth (*e.g.* plant height) from greenhouse studies conducted under conservative conditions that ensure exposure at measured doses as opposed to field studies that test phytotoxic effects under more variable environmental conditions. From these greenhouse studies, EPA relies upon the most sensitive species' Effective Concentration (EC_{25}) or Inhibition Concentration (IC_{25}) that resulted in a 25% reduction and the associated NOAEC (No Observed Adverse Effect Concentration) from the same test as the effect thresholds to determine whether exposures are above the threshold level and consequently have the potential to cause risk to non-target plant species. EPA also commonly calculates a regression estimate of the 5% effect level (EC_{05} or IC_{05}) that is used in lieu of the NOAEC when a NOAEC cannot be determined from the study.

Based on a comparison of EC_{25}/IC_{25} values for plant height and weight across a suite of tested species, EPA determined soybeans to be the most sensitive species from the available greenhouse-based toxicity assays (**Appendix C**). The most sensitive soybean endpoint was based on a plant height IC_{25} (0.000513 lbs a.e./A) with a corresponding NOAEC of 0.000261 lbs a.e./A (MRID 47815102). As discussed in USEPA 2013c[12], there was a 9% reduction at the 0.000261 lbs a.e./A concentration that was not statistically different from controls in the study [13]. A review of the open literature on the toxicity of dicamba to other terrestrial plants (including field- and greenhouse-based studies) showed that the available soybean IC_{25} endpoint was more sensitive than the other tested species in registrant studies as well as the open literature (*e.g.* Knezevic et al. 2018). As such, EPA utilized soybean as a reliably representative species for evaluating potential effects to sensitive non-target plant species.

1.7.3. Relationship of Height and Yield

Reported incidents following the use of dicamba have included reports of reduced yield in soybeans and other crops (see discussion in Appendix I). Because the typical greenhouse studies do not capture measures of plant reproduction (e.g., yield), EPA also considered several dose response field-based toxicity studies that included a measurement of yield. These studies were published in the open literature or submitted by registrants. These data include a set of common field-based studies submitted as part of the terms of the 2018 conditional registrations of XtendiMax, Engenia and Tavium.

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[12] USEPA 2013c. Memorandum: Addendum to the Data Evaluation Report on the Toxicity of Clarity 4.0 SL (AI: Dicamba) to Terrestrial Vascular Plants: Vegetative Vigor (MRID 47815102).

[13] EPA does not rely upon this endpoint to estimate how far off-field reductions of 5% reductions in height or yield could be reasonably expected. As a result, the discordance between the observed effect at this NOAEC (9%) versus the target of 5% reductions height and yield, has no impact of the on the conclusions of the assessment

The registrants for these products conducted several soybean toxicity studies which exposed plants to various doses of dicamba and measured plant height, VSI, and yield under conditions of an exposure at vegetative or reproductive growth stages (**Appendix C**). In each study, plant height followed an expected dose response pattern of decreased plant height when plants were exposed to progressively higher doses. Three of the 10 studies did not have reductions in yield when compared to controls, however the other seven studies showed dose response reductions in yield as compared to the controls. Across these seven studies, that had shown effects to yield, the IC_{25}s for height and yield reflected similar sensitivities (within a factor of 2x). Furthermore, the endpoints following exposure at either the vegetative or reproductive growth stage were similar, such that both height and yield endpoints are applicable to exposures during either growth stage and selecting the most sensitive overall would be appropriate and protective. In addition, several open literature studies (**Appendix C**) provided measurement endpoints for yield and generally show a consistent pattern with the registrant submitted data. Based on these lines of evidence, EPA determined that plant height is protective of yield.

1.7.4. Visual Signs of Injury (VSI)

Many of the available Off-Field Movement (OFM) field studies investigating plant response to off-field dicamba exposure report the measurement of VSI as the only plant endpoint for the study. Most of these studies share a similar study design and VSI scoring system. EPA investigated multiple lines of evidence to inform whether the use of such information in this risk assessment would be appropriate to determine an protective measurement endpoint of VSI. The lines of evidence EPA used to determine the appropriate endpoint selection for determining risk included:

- consideration of the dicamba herbicidal mechanism of action (MOA) and whether VSI and height or yield effects are grounded in a common biologically relevant mechanism (**Appendix C**);
- the biological implications of dicamba exposure at specific growth stages of tested plants and the whether there are relationships between VSI and other effects (**Appendix C**); and
- an evaluation of VSI observations relative to observations of height and yield effects in dose response studies to explore whether there are quantitative relationships between VSI and height or yield effects (**Appendix D**).

The following sections describe EPA's conclusions regarding each of these lines of evidence.

1.7.4.1. Considering the Dicamba Herbicidal Mechanism of Action (MOA)

The mechanism by which dicamba causes epinasty and meristematic inhibition, rapid abnormal growth through the auxin-like characteristics of dicamba, is the same mechanism that ultimately disrupts the nutrient flow of the plant leading to reduced growth and reproduction. EPA provided a fuller discussion of dicamba's MOA and its relationship to height and yield, along with brief discussions of the studies reviewed for estimating VSI responses as they relate to the endpoints for height and yield in **Appendix C**.

1.7.4.2. Evaluation of %VSI observations relative to 5% Height and 5% Yield reductions

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Relying upon measures of plant height and yield reductions and VSI, EPA determined that there is a reasonable and protective measurement of %VSI to represent 5% height reductions. Determining whether this relationship exists is important because, as mentioned before, many available field-based studies only reported plant effects in terms of VSI. Therefore, to make the best use of the available data, and to be inclusive of a much greater representation of geographic, climatic and temporal variability in areas of high levels of reported dicamba related incidents, EPA established a relationship between plant height and VSI. EPA considered studies conducted in the greenhouse as well as in the field, that included direct application, vapor phase, and spray drift-based exposure which measured VSI and plant height or yield. The pool of available data included 22 studies with 111 individual %VSI:5%height ratios, and 11 studies with 40 individual %VSI:5% yield ratios (**Appendix C**). From these data, EPA used probabilistic tools to establish a single %VSI at 5% Height (**Appendix D**). EPA determined that 10% VSI represents the 5th percentile of the distribution that correlates %VSI to a 5% reduction in height. The 5th percentile represents a conservative relationship such that 95% of the data suggests a greater amount of VSI would be required to achieve a 5% reduction in height. The evaluation of %VSI to 5% yield reduction was less straightforward, and the analyses did not result in a reliable relationship (see discussion in **Appendix D**). As described in **Section 1.7.3.**, using studies that evaluated both height and yield, EPA determined that height was protective for yield, therefore the measurement of 10% VSI is also considered protective of 5% yield.

EPA used the measurement of 10% VSI along with the measurement of 5% height to evaluate the distance away from a treated field where there are plant responses to dicamba as a result of off-field movement (*e.g.,* spray drift, volatility). In turn, this information helped to assess whether the mandatory in-field setbacks on the labels were adequate to address spray drift and volatile emissions, such that any effects to non-target organisms would be limited to the treated field.

1.7.5. Use of 10% VSI and 5% plant height for interpreting distance to observed effects in field studies

Assessments for previously registered dicamba products for use on DT crops, EPA used plant height measurement endpoints that were derived from greenhouse studies coupled with modeling (e.g., AgDRIFT, TerrPlant) and field based measures of plant height to establish distances to where there would be no risks of concern. Following the registration of these products, reports of off-site incidents (primarily reported as VSI) suggested potential movement of dicamba at levels causing observable plant responses to dicamba exposures (AAPCO, 2017, 2018) at distances beyond what was expected from the earlier reviews. In this current assessment, EPA has evaluated a robust set of field-based toxicity data to estimate the potential for off-field effects to plants. Because of this dataset, EPA has high confidence that this body of information provides a fuller understanding to what is happening in the field.

In this comprehensive assessment, EPA reviewed large set of field-based toxicity studies (OFM studies) that provide measurements of VSI and plant height as it relates to distance from dicamba treated fields. All of the available OFM studies include measures of VSI with fewer including plant height. Under field conditions, the measurement of VSI is less variable and is not directly influenced by other field conditions, whereas plant height can be highly variable across the expanse of a field. The OFM studies were not designed to capture a no-effect level (NOAEL) for measures of plant effects, but rather plant effects as they radiate out from a treated field. In guideline terrestrial plant greenhouse-based studies, when a NOAEL/NOAEC is not reliably established, EPA considers a 5% threshold interpolation (regression estimate when comparing doses and biological effects). Additionally, in the absence of a NOAEL/NOAEC, EPA uses the EC_{05}s from available endpoints to complete effects determinations for listed species

(USEPA, 2004). Therefore, EPA relied upon a 5% effect level for plant height, and, as discussed in section 1.7.4., 10% VSI to estimate distances to effects within each OFM study.

1.7.6. Establishing the Distance from Treated Fields Where Adverse Plant Effects Occur

EPA evaluated spray drift and volatile drift exposure to terrestrial plants in the off-site areas, using large field-scale OFM toxicity studies (**Appendix E**). EPA relied upon regression techniques to establish correlations between distance and plant effects in order to establish the distances to 5% height reduction as well as to 10% VSI. To make maximum use of the available field data, EPA has developed a probabilistic, distributional approach for determining a reasonable upper bound estimate for the distance from the field to plant effects.

1.7.7. Off Field Movement (OFM) Studies

OFM studies are designed to have a crop of dicamba tolerant soybeans surrounded by a crop of non-tolerant soybeans. A single application of dicamba is made to the tolerant crop and the movement of dicamba is measured with spray deposition cards and air samplers to capture the amount of and direction of off-field dicamba movement. Transects (sampling locations) radiate out from the treated area to provide measures of %VSI and/or plant height at distances from the treated area. Two pathways of exposure are typically evaluated, spray drift (primary exposure) and volatility (secondary exposure). Many of the OFM studies included areas (transects) covered with tarps during application to prevent spray drift deposition, thereby allowing an evaluation of plant effects influenced solely by volatility-based exposure, as well as uncovered transects which were exposed to dicamba through both spray drift and volatility-based exposure.

EPA reviewed all registrant submitted studies and studies conducted by weed scientists in academia that provided a measure of the effects at certain distances from the application of XtendiMax, Engenia or Tavium products. EPA's distance to effect determinations represent a large pool of data that encompasses field trials, under variable environmental conditions and performed in a wide distribution of geographic locations including regions with high numbers of incidents reported. EPA has high confidence that this body of information provides a fuller understanding to what is happening in the field.

With the covered or uncovered transects, it is possible for EPA to establish distance to effect for volatility-based exposures separately from spray drift + volatility. Thus, EPA can separately consider control measures on the label for protecting terrestrial plants and habitats from dicamba volatility or the combination of spray drift and volatility. The labels require an in-field downwind spray drift setback (to address any concerns related to spray drift) as well as an in-field omnidirectional volatility setback (to address any concerns related to volatility).
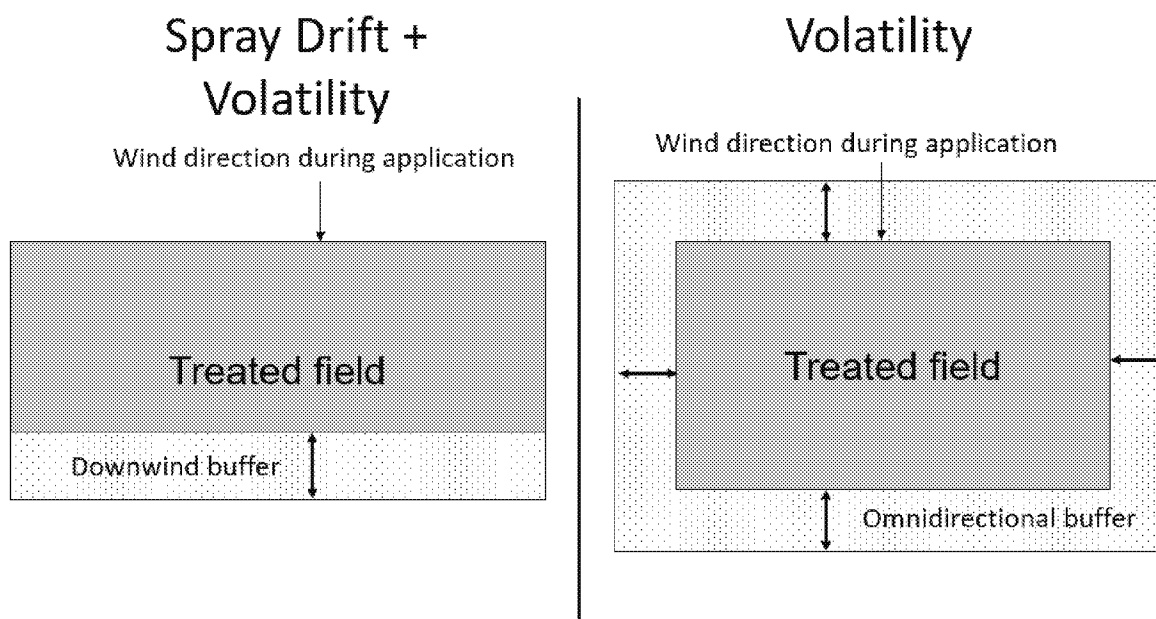
Figure 1.1. Illustration describing the conceptual diagrams of in-field spray drift "downwind" and volatility "omnidirectional" setbacks.

Based on the review of the OFM studies, EPA determined that the measures of plant height were highly variable, due in part to effects from other conditions in the field (e.g., soil moisture, topography, insolation). Visual signs of injury are a direct response of the plant to the disruption caused by the dicamba mechanism of action (**Appendix C**) and provide a plant response that is less influenced by environmental conditions. Therefore, VSI has less uncertainty in the causality of the observed effects and as a result EPA has greater confidence in the distance to measures of VSI than distances estimated with plant height.

1.7.8. Distributional Approach to Establishing Off-Field Distance of Dicamba Plant Effects

EPA's approach to establishing off-field distance to plant effects uses a reasonable upper bound estimate for establishing the levels of dicamba exposure at varying distances. This is the same approach EPA used for exposure estimation in 1) aquatic phase organisms using the PWC model and 2) refined spray drift exposure for terrestrial and aquatic organisms using the AgDRIFT model. In addition, previous effects determinations for dicamba used a reasonable upper bound estimate for volatile drift exposure for using the PERFUM model. For this assessment, considering both spray drift and volatile drift exposure to terrestrial plants in the off-site areas, EPA developed a probabilistic, distributional approach to determine a reasonable upper bound estimate for the distance from the field to plant effects, combining the effects-to-distance data from all of the reliable field studies (see **Appendices E and F**).

EPA created separate probability distributions for spray drift + volatility (informs the in-field downwind spray drift setback) and volatility (informs the in-field omni-directional volatility setback) for the following data sets:

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Spray drift-related distance to plant effects:
1. Distance from the treatment field edge to a point related to direct estimate of 5% height for all field spray drift + volatility (uncovered) transects reporting height
2. Distance from the treatment field edge to a point related to direct estimate of 10% VSI for all field spray drift + volatility (uncovered) transects reporting VSI.

Volatile emissions-related distance to plant effects:
3. Distance from the treatment field edge to a point related to direct estimate of 5% height for all field volatility (covered) transects reporting height.
4. Distance from the treatment field edge to a point related to direct estimate of 10% VSI for all field volatility (covered) transects reporting VSI.

EPA used Crystal Ball add-in software to Excel to fit distribution functions to the data sets. Crystal Ball enables the user to fit various probability distribution functions to a data set and then sample those distributions thousands of times using Monte Carlo probabilistic algorithms to test the extent to which the selected distributions tend to over or underestimate any segment of the distribution of the variable. Because EPA is interested in reasonable upper bound estimates (protective) for the distance to effects analysis, the Agency selected a distribution to fit to the data that would be a more accurate representation of the dispersion of data at the upper limits of the distribution. EPA considered the fit reasonable if when comparing the data, the fit distribution and the distribution of randomly sampled values were consistent.

Table 1.20 provides the 90th and 95th percentile distances for the uncovered and covered transects. The Crystal Ball output for each distribution and more discussion is provided in **Appendix F**. EPA found good agreement between data, fit distribution, and resampled distribution in all cases up through the 95th percentile. The results imply that dicamba can cause plant response in excess of 10% VSI as far as 240-310 ft (for downwind spray drift + volatility) and 110-160 ft (omnidirectional volatility) from the treated field. As mentioned above, there is greater uncertainty in the distances estimated with direct measure of plant height because plant height is affected by other conditions in the field (e.g., soil moisture, topography, insolation) and there is a smaller dataset available for plant height. As a result, distance estimates for height are less robust than those that consider the measurement of VSI. In addition to having lower environmental influence than height, the use of the measurement of VSI allows for the inclusion of a greater geographic and temporal representation because there are several studies that did not measure plant height.

Table 1.20. Estimated distance to effects thresholds for protecting growth and reproduction of sensitive vegetation from spray drift and volatility based dicamba exposure pathways.

Probability assuming best fit distribution	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
	10% VSI (N=105)	5% plant height (N=73)	10% VSI (N=76)	5% plant height (N=41)
95th percentile distance	310	330	160	66[1]
90th percentile distance	240	240	110	46

[1] Given the variability of the data for plant height, EPA concluded that the distances to 10% VSI represent a more robust and environmentally representative measure of distance to effect.

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1.7.9. The Effect of Labeled Spray Drift and Volatile Emissions Control Measures on Off-field Non-Target Risk for Non-listed Plants

As discussed earlier in the document, labels for the dicamba products to be used on DT crops contain a variety of mandatory spray drift and volatile emissions control measures. Among these requirements are:

- Spray Drift Requirements
  - Application equipment must use spray nozzles and pressure settings from an approved equipment list maintained at www.engeniatankmix.com, https://www.syngenta-us.com/herbicides/tavium-tank-mixes , or www.XtendiMaxapplicationrequirements.com, product dependent.
  - XtendiMax® With VaporGrip® Technology must be mixed in solution with an approved drift reduction adjuvant as specified on the approved list maintained at www.XtendiMaxapplicationrequirements.com.
  - Use only approved tank-mix partners from a list maintained at www.engeniatankmix.com, https://www.syngenta-us.com/herbicides/tavium-tank-mixes, or www.XtendiMaxapplicationrequirements.com , product dependent.
  - Application is only allowed by ground spray equipment and with a maximum spray boom height of 24 inches above pest or crop canopy
  - Application can only occur when boom-height wind speed is between 3 and 10 miles per hour.
  - DO NOT spray during an inversion; only spray between one hour after sunrise and two hours before sunset.
  - Each product label requires a downwind 240-foot in-field spray drift setback (buffer) for all application sites

- Volatile Emissions Requirements
  - XtendiMax® With VaporGrip® Technology must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.XtendiMaxapplicationrequirements.com.
  - Engenia® herbicide must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.engeniatankmix.com.
  - Tavium® herbicide must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at http://www.syngenta-us.com/herbicides/tavium-tank-mixes.
  - Application of products to soybean are prohibited after June 30 or the soybean R1 growth stage.
  - Application of products to cotton are prohibited after July 30.

EPA considered the individual contribution of each of these label requirements in the context of their impact to off-field risks to non-target plants. The evaluation of spray drift impact logically extends to areas adjacent to the treated field where transport of spray drift droplets is most acute. The evaluation of the impacts of volatile emissions control measures includes both a consideration of their impact in the near field areas and over a wider area to include the scale suggested by available plant incident data (as evaluated in the sections above and in **Appendices F and I**).

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1.7.9.1. Spray Drift Control Measures Impacts to Off-Field Plant Risk

The mandatory spray drift control measures of wind speed and inversion limits, requirements for spray nozzles and tank mix approvals and drift reducing agents, and boom height limits were taken into account by the distance to plant effect predictions presented in the above off field analysis. This is because the underlying field studies establishing distances to plant effects have incorporated these measures as part of the study protocol.

For counties without listed species, the labels require a 240-foot in-field setback on downwind margins of the treatment area during application. As shown in **Table 1.20** above, this would provide a 90% confidence that no adverse effects to non-target plants would result in from dicamba spray drift or volatility at the downwind edge of the treated field.

As described above, EPA estimated the distance to effect using the available OFM studies submitted by the registrants and academia (**Appendix E**). When determining the off-field distance to effect (**Appendix F**), while the majority of the studies (88%) included a drift reducing agent, Intact®, there were mixed results on drift reduction. Studies including Intact® had the largest as well as the smallest distances to effect. As such, the inclusion of a drift reducing agent into the tank mix did not have a significant impact on reducing the distance to effect.

Additionally, EPA evaluated the optional use of hooded sprayers for soybeans (**Appendix O**). The distributional analysis of distances from data submitted to EPA from hooded sprayer field trials performed with Crystal Ball suggests that, with this limited data set, the distances to a soybean NOAEL would not extend beyond 20 ft with 95% certainty.

EPA did not use the soybean NOAEL to establish the original distance to effects analysis. Analyses have shown that the distances to 10% VSI (the measurement used for distance to effect **Section 1.7.6**) is reasonably expected to extend further from NOAEC based distances by a factor of 2 to 5.

To address the limited information provided to EPA and to address the potential for further distances to the 10% VSI threshold relative to distances to the soybean NOAEL, the hooded sprayer option includes a requirement for in-field setbacks. The combination of the in-field setbacks with the hooded sprayer moves the sources of dicamba further away from the field edge by a factor of 5x (110 ft).

1.7.9.2. Volatile Emission Control Measures Impacts to Off-Field Plant Risk

The labels also include a requirement for an in-field omnidirectional 57-foot volatility setback to protect against near-field impacts in select counties where there are listed species. While this requirement does not apply to all cotton and soybean-growing areas, where present, this setback serves to reduce dicamba exposure for non-listed plants. The analysis summarized in **Table 1.20** suggests that an in-field 57-foot omnidirectional volatility setback serves to reduce volatilized dicamba exposure to plants at the margin of the treated field to a level that would not exceed a conservative plant height effect endpoints between 90 and 95 percent of the time.

The labels for the dicamba products for use on DT crops require an approved volatility reduction agent (VRA) to prevent the DGA and BAPMA salts of dicamba from converting into dicamba acid. The analysis of the performance of VRAs in dicamba product application tank is presented in **Appendix F**. This analysis shows that the use of VRAs reduces volatility of dicamba to the point where movement of

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volatilized dicamba will not exceed conservative plant effects thresholds 89% (**Appendices F** and **J**) of the time at the very edge of the field. This represents a significant reduction from the distances at which volatile dicamba produced effects are seen in **Table 1.20**. In addition to this reduction in near-field effects, such reductions in localized emissions and effects, when viewed over the wider landscape, addresses the potential for wide-area effects from the use of the dicamba products. As discussed below, this in combination with additional label requirements that address volatility, provide EPA with high confidence that risks of concern from volatile emissions are addressed.

Another factor that drives volatility is temperature, which tends to increase during the growing season. Appendix I presents EPA's evaluation of dicamba application cut-off dates, relative to temperature and known incidents, for soybean and cotton. The analysis considered multiple lines of evidence, including: laboratory volatility data, field effects data, air modeling, plant incident reports, and meteorological data. Based on this analysis, EPA concluded that reduced temperatures at the time of application can reduce the volatility of dicamba. Reducing the ability of dicamba to volatilize, in turn results in a reduction of the potential of off-field emissions of dicamba associated with non-target plant effects. Therefore, if application is prohibited on days where temperatures favor volatile emissions, incidents would be avoided. When considering favorable volatility temperatures in the context of crop planting schedules and meteorological data, labeled dicamba application cutoff dates reduce applications coinciding with temperatures favoring dicamba volatility and by extension incidents. Because the dates are the same in all 34 states and the meteorological data vary across these geographies, the magnitude of the protective certainty of cut-off dates is not uniform across the 34 states, but in no state was the probability of avoiding a problematic temperature on the day of application zero. The use of a cut-off date produced avoidance of applications of dicamba on days with temperatures favoring volatility and is expected to provide protection of both effects at the near field level as well as on scales suggested by available incident data.

1.7.10. Analysis of Incident Data Relative to Select Temperature Thresholds

EPA conducted analyses to quantify the effect of temperature on the frequency of off-site incidents, in order to quantify the number of incidents that might have been avoided, if maximum application temperature restrictions had been in effect.

In order to establish proximity of an incident to the alleged source site of dicamba and use the associated application data to compare with geographically maximum temperature data on the reported day of application EPA applied the following criteria to available incident reports:

1. A reported incident must have a reported application date for the incident
2. The incident must have reported latitude and longitude coordinates
3. The incident must have a reported distance from spray to affected site

Reports of dicamba plant damage were available from multiple sources. The predominant sources of incidents were from Bayer's Off-target movement (OTM) Inquiries reports for 2017, 2018 and 2019 submitted under FIFRA section 6(a)(2) and BASF's Off-Target Report for the same time period. These two combined sources provide almost 5600 reported incidents. In addition, two non-governmental organization survey reports were available to the Agency. One is an Audubon Arkansas reported on a dicamba symptomology community science monitoring effort (Scheiman 2019). The other is a Prairie Rivers Network (PRN) tree and plant health monitoring report (Prairie Rivers Network 2020).

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Available 6(a)2 Incident Information Summary

Table 1.21 summarizes the states with reported damage from the 5600 incidents reported in the 6(a)2 submissions. A total of 29 states within the 34-state growing area for cotton and soybean have reported incidents.

Table 1.21. A summary table of the number of 6(a)2 incidents per state

State	Number of Incidents
IL	1453
IA	800
MN	665
SD	485
MO	387
KS	300
IN	298
NE	275
ND	238
OH	107
AR	85
KY	72
TN	70
MI	59
NC	39
MS	37
LA	28
OK	17
PA	15
GA	11
TX	10
VA	10
WI	9
MD	8
AZ	5
AL	3
NY	3
SC	3
NM	1

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Table 1.22 summarizes the crop type with reported damage from the same 5600 incidents reported in the 6(a)2 submissions. Soybeans are the dominant crop associated with incident reports.

Table 1.22 Summary of the number of 6(a)2 incidents by crop type

Crop Type	Number of Incidents
Soybeans	5458
Peaches	32
Cotton	28
Unspecified	25
Tobacco	21
Alfalfa	10
Tomatoes	8
Vegetables	6
Garden	4
Grapes	4
Peanuts	4
Oak Trees	3
Sunflowers	3
Blackberries	2
Canola	2
Hemp	2
Peas	2
Pinto Beans	2
Pumpkins	2
Potato	2
Apple Trees	1
Aronia Berries	1
Corn	1
Flax	1
Fruit Trees	1

Out of the nearly 5600 FIFRA section 6(a)2 incidents reported, a subset included sufficient information to allow EPA to establish a distance from a suspected dicamba use site to the affected plants. A total of 493 incidents provided this information. The spread of distances from suspected application site to incident ranged from the treated field edge (0 feet) to 8,089 feet. In order to evaluate volatility that would not be prevented by the in-field omnidirectional 57-foot volatility setback, EPA selected all incidents that occurred 50 feet or beyond the reported dicamba source site. This distance approximates the 57-foot omnidirectional volatility setback label requirement at the time of dicamba applications.
. Two-hundred and seventy-nine (279) out of 493 incidents occurred beyond this distance. EPA performed an additional sorting of incidents at a distance of 110ft and beyond the dicamba application site. This sorting was to evaluate incidents that occurred beyond the limits of expected spray drift. The 110-ft distance corresponds to the in-field downwind 110-ft spray drift setback in place on product labels at the time of incident reporting. The analysis revealed that 124 incidents occurred at distances equal to or greater than 110 feet from a suspected dicamba source.

Within the 6(a)2 reports there are no comprehensive notes on misuse. However, EPA identified two incidents where the wrong nozzle was used and four incidents with no in-field setbacks employed.

In summary, the available FIFRA section 6(a)2information indicates that incidents occurred over the majority of the cotton and soybean growing states. The sensitive non-dicamba resistant varieties of the soybean plant represent the majority of impacted crops reported in the incidents, though a variety of woody and herbaceous species were also reported as impacted. Incidents were reported at distances beyond the required volatility and spray drift in-field setbacks on the labels at the time of reporting.

Audubon Study Summary

Audubon Arkansas reported on dicamba symptomology in plants using a community science monitoring effort (Scheiman 2019). Audubon Arkansas trained volunteers to look for symptoms associated with a plant growth regulator (PGR) herbicide (includes dicamba). Symptoms included leaf cupping, epinasty, and chlorosis. Volunteers were instructed to look for more than one symptom on a plant, uniform symptomology across a plant, and for incidents where multiple plants and species in an area displayed symptoms. Volunteers took photos of plants meeting those criteria which were subsequently reviewed by experts who rated them as probably, possibly, or unlikely to be showing symptoms consistent with a PGR herbicide. Of the 344 records and 728 photos submitted from 17 counties,178 records contain at least one photo showing symptoms consistent with a PGR herbicide, and 65 possibly show such symptoms. Species displaying probable or possible symptoms include Carolina buckthorn, catalpa, elms, hackberry, hibiscus, morning glory, magnolias, maples, mulberry, muscadine, oaks, pears, pecan, pepper vine, pokeweed, redbud, smooth sumac, sweetgum, sycamore, trumpet vine, tulip tree, and white popular. Sycamore (96 locations) was the most frequently reported species. There are 13 locations where the report indicates volunteer observations were made within two miles of an Arkansas plant board positive testing for dicamba. While the report included 213 tissue samples collected from 86 sites that tested positive for dicamba, EPA cannot confirm the reported distances of incident to the measured tissue sample locations from the available information.

The lack of survey distinction of 2,4-D and dicamba damage symptomology and findings that other PGR herbicides cooccurred in tissue sampling sites precludes definitive conclusions regarding the cause of observed plant symptoms

Prairie Rivers Network Summary

In 2018, PRN launched a volunteer monitoring program to investigate the increase in landowner reports of suspected herbicide injury to trees and other broadleaf plants (Prairie Rivers Network 2020). PRN's volunteer monitoring program is not intended to identify the cause of injuries, but merely to serve as a rapid ecological assessment in order to document the presence and prevalence of symptoms of possible off-target herbicide exposure through the documentation of visual symptoms consistent with PGR herbicide drift exposure. In order to verify exposure of herbicides in species or locations that were of particular interest, a small number of tree leaf samples were analyzed for PGR herbicides. Results confirmed that 20 of 24 tree leaf samples had detectable levels of either 2,4-D, and/or dicamba residues present at the time of sampling. PRN's monitoring program concluded that symptoms of possible off-target herbicide injury were frequent and widespread, and present in a wide variety of plant types in the regions that were monitored. A total of 70 species were monitored and all showed symptoms. Ratings of symptom severity ranged from light to severe and varied by location and species. In 2018, 45 out of

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49 locations had at least one species with symptoms that were moderate or greater in severity. Of those, 29 had species where symptoms were severe. In 2019, 59 of the 83 locations had species with symptoms that were moderate or higher; 28 species had symptoms that were severe.

The lack of survey distinction of 2,4-D and dicamba damage symptomology precludes definitive conclusions regarding the cause of observed plant symptoms.

1.7.11. Terrestrial Plant Exposure via Runoff

Dicamba is a soluble, mobile chemical and would be expected to affect nontarget terrestrial plants in areas adjacent to treated fields if runoff were to occur. In an effort to mitigate damage from runoff, the label on previously registered dicamba products for use on DT crops included the restriction "DO NOT apply if soil is saturated with water or when rainfall that may exceed soil field capacity is forecasted to occur within 24-48 hours." However, even with this restriction, offsite plant damage resulting from runoff occurred in a number of the off-field movement studies (**Appendix E**), particularly the studies conducted in Mississippi where a heavy rainfall (approximately 4 inches precipitation in one day[14]) event occurred on day 2 of the studies, as well as an academic study conducted at the University of Missouri (**Appendix E**). Additionally, results from a runoff study (**Appendix G**) indicate that runoff occurring 7 days after application can reach concentrations of dicamba (5.62×10^{-4} lb/A) sufficient to exceed the most sensitive terrestrial plant IC_{25} (5.13×10^{-4} lb/A).

To examine the impact of runoff of dicamba from treated fields under field conditions, EPA ran PWC (PRZM only) using the Mississippi (MS) soybean scenario, adjusting the curve numbers (from 84 when a crop is present and 87 when the field is fallow to 82 and 88, respectively) to be more representative of typical, good hydrologic conditions[15]. EPA also replaced the meteorological file with one that had 1 inch of precipitation occurring 1-30 days after the application date (5/15) to explore potential rain-fast durations. EPA used the same fate parameters as in its aquatic modeling (**Table 1.2**).

Mass loss results in the modeling were comparable to those that were observed in the runoff study: 0.19% for runoff occurring 1 day after application (study value was 0.25%) and 0.15% for runoff occurring 7 days after application (study value as 0.12%). Modeling concentration results were higher than, but comparable to, those observed in the runoff study when calculated using the acreage of the treated field in the runoff study (1.34 A): 5.42×10^{-4} lb/A for runoff occurring 1 day after application (study results are 1.33×10^{-3} lb/A) and 4.14×10^{-4} lb/A for runoff occurring 7 days after application (study results are 5.62×10^{-4} lb/A). Runoff values for the modeled, treated field drop below the vegetative vigor IC_{25} for soybeans (5.13×10^{-4} lb ae/A) for runoff events occurring 3 days after the application. However, for a 10-ha (25 A) field, runoff values for a modeled, treated field never drop below the IC_{25} for soybeans, starting at 9.72×10^{-3} lb/A for runoff occurring 1 day after application and ending with a value of 2.82×10^{-3} lb/A for runoff occurring 30 days after application.

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[14] Based on the PWC Mississippi meteorological file associated with cotton and soybean, this represents a 1 in 5 year rain event.

[15] Obtained from Chapter 9 of Part 630 Hydrology National Engineering Handbook for Row Crops, Straight Row and Crop Residue Cover, Good Hydrologic Conditions and a Hydrologic Soil Group of C and Fallow, Crop Residue Cover, Good Hydrologic Conditions (USDA, Natural Resources Conservation Service 2004).

If ¾ in of rain were used in the modeling, concentration results for a 10-ha field dropped below the IC_{25} for soybeans by 13 days after application. If the aerobic soil metabolism half-life is set equal to 6 days, then the runoff values for a 10-ha field drop below the IC_{25} for soybeans 6 days after application. For ½ in of rain, the model predicts that runoff does not occur; however, this is most likely the result of the "initial abstraction" (i.e., the amount of water lost prior to runoff, due to processes such as infiltration, interception, evaporation) being larger than the rain event. This was already accounted for in the runoff study, where approximately 0.25 to 0.39 inches of water were applied as simulated rain and runoff was being promoted.

Based on this analysis and the results from the runoff study, as well as observed effects to non-target plants in the OFM studies, there is a potential risk of concern to non-target terrestrial plants due to runoff. However, if applications are not made when the soil is saturated with water or when rainfall that may exceed soil field capacity is forecasted to occur within 24-48 hours, as was done with the modeling, then risks to non-target plants will be reduced. The level of reduction cannot readily be quantified due to site-specific conditions such as field size, amount of saturation in the field at the time of the event, soil-type, hydrologic conditions, etc.

2. ESA Effects Determination

The ESA effects determination evaluated whether the federal action poses any reasonable expectation of discernible effects to listed species and designated critical habitats within the action area. The ESA effects determination makes use of the best available scientific information and considered both direct and indirect effects.

2.1. Methodology Overview

As summarized in reports to Congress,[16] EPA has a specific process that it follows when assessing risks to listed species from pesticides like dicamba that will be used on plants genetically modified to be tolerant to the pesticide. **Figure 2.1** depicts the overall process and a general description of the major steps in the process are presented here and discussed in more in following sections.

The Agency begins its assessment of risks to listed species with a screening level assessment (see Section 1) that includes a basic ecological risk assessment based on its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at https://www.epa.gov/sites/production/files/2014-11/documents/ecorisk-overview.pdf].
If the screening level assessment identifies no potential risks of concern for a particular taxonomic group, EPA considers any listed species within this group as not affected ("no effect" determination) by the action regardless of their location and no further work required for these species.

Conversely, when any given taxonomic RQ exceeds either the acute or chronic listed species LOC for a taxonomic group, EPA then performs a species-specific effects determination. An exceedance of a LOC does not mean that the action may affect a species. Instead it means further review is needed to determine whether the action may affect a specific listed species or its designated critical habitat. This process includes:

1. A determination of the geographical extent of the action area (the area where identified effects are expected to occur)
2. A determination of whether a listed species is located within the action area
3. For species outside the action area, no further analysis is performed as these species as they are unaffected.
4. For species within the action area, EPA conducts a species-specific risk assessment for direct effects and an evaluation of indirect effects

The Agency also follows a similar habitat-specific analysis for Critical Habitat effects determinations using

1. The action area described above
2. A determination of whether a critical habitat is located within the action area
3. If a critical habitat is not in the action area no further analysis is required

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[16] https://www.epa.gov/endangered-species/reports-congress-improving-consultation-process-under-endangered-species-act; https://www.epa.gov/sites/production/files/2015-07/documents/esareporttocongress.pdf

4. If critical habitat is within the action area:
    a. A determination is made regarding the habitat's principal constituent elements (PCE) or physical/biological factors (PBFs) and whether they are provided by the action area or the critical habitat specifically identifies row crops (cotton and soy) as part of the critical habitat, and
    b. A comparison of PCE's PBF with risk assessment conclusions is made to determine if the risks from dicamba affect these attributes.

2.2. Screening Level Analysis and Results

The FIFRA risk assessment described in **Section 1** served as the screening level assessment for determining which taxa needed further review. For some taxa (freshwater and estuarine/marine fish and invertebrates and aquatic plants) the screening level assessment indicated no risk concerns using conservative assumptions of toxicity and exposure. Therefore, EPA determined that a species-specific assessment was not necessary, and no effect determinations could be made for these taxa. However, as identified in **Section 1**, other taxa needed further review at the species-specific level to determine whether the action may affect any listed species or their designated critical habitat. The taxa needed further review include:

*   Mammals (soybean use only, due to residues from dicamba's metabolite DCSA, rather than from parent dicamba)
*   Birds, reptiles, and terrestrial-phase amphibians (both soybean and cotton uses from the parent dicamba; chronic from DCSA residues only in soybean),
*   Terrestrial Invertebrates (soybean and cotton uses from parent dicamba)
*   Terrestrial plants (soybean and cotton uses from parent dicamba) with narrowed emphasis on non-monocot plant species (**Section 1.7** and **Appendix C**)
*   Aquatic unicellular plants were identified as a possible taxon for additional evaluation for effects to listed species, however unicellular plants are not identified by the Services' listings of federally listed threatened or endangered species and no further effects determination refinement efforts were appropriate for this taxon.

For the taxa needing further review, EPA then applied a refined species-specific and critical habitat assessment process to complete an effects determination.

Screening level risk assessment — **1.0**

Does a taxonomic group require further review? — **2.1**

no → Listed species within this group are not affected regardless of their location; no further work required for these species — **2.1**

yes

Proceed with species specific effects determinations for these taxa — **2.2**

Establish the action area — **2.2.1**

Describe the federal action (labeled uses and locations) **2.2.1.1** → Determine distance from use sites where effects are expected to occur (spray drift + volatility) **2.2.1.2** → Create a GIS Layer for the action area — **2.2.1.3**

Determine species ranges and Critical Habitats (CH) — **2.2.2**

Consult Services' location and habitat information → Create list of Species Ranges and CH in states labeled for use → Create GIS layers of species ranges and CH locations

Species Range or CH not in action area, end analysis as they are outside the action area and not affected

no

Overlap analysis: Are species ranges or CH in action area? — **2.2.3**

yes

Risk-based Species Specific — **2.2.4** or CH Specific Analysis — **2.2.5**

Consult Services' biological information → Conduct species specific risk assessment / Consider indirect effects → Is there risk to species or resource? — no → No Effect / yes → May Effect

Consult Services' CH information (PCE/PBF) → Are there any affected PCE/PBF's provided by the action area, or is the species itself affected in the action area? — no → No Effect / yes → May Effect

Numbers refer to sections in the document

Figure 2.1. Overview of Effects Determination Process for Evaluating Listed Species and Associated Critical Habitat

2.3. Proceeding with Species Specific Effects Determinations

2.3.1. Establishing the Action Area

The action area is the footprint of the federal action plus any additional areas where effects are reasonably expected to occur. To establish this action area EPA performed three steps:
1. Conducted a full review of the federal action which includes a review of the labeling to determine the application requirements and restrictions, the sites of dicamba product use, and any geographical restrictions.
2. Considered information from **Section 1** and supporting appendices to determine how far off the site of application effects are expected to occur.
3. Established a geographical information data layer (GIS layer) that combines the sites of use with the extent off-site areas where effects are reasonably expected to occur.

2.3.2. Describing the Federal Action

The dicamba registration actions considered in this ecological risk assessment for pre- and post-emergent use are the following restricted use products:

- Tavium Plus VaporGrip® Technology [diglycolamine (DGA) salt of dicamba 17.7% a.i. and S-metolachlor 24.0% a.i.],
- Engenia® [N,N-Bis-(3-aminopropyl)methylamine salt of 3,6-dichloro-o-anisic acid (BAPMA) 60.8% a.i.], and
- XtendiMax® With VaporGrip® Technology, Alternative brand name: M1768 Herbicide [diglycolamine (DGA) salt of dicamba (3,6-dichloro-o-anisic acid) 42.80% a.i.].

The labels that EPA assessed allow for 2 applications of 0.5 lbs acid equivalent (a.e.) dicamba per acre (0.5 lb a.e./acre) as a pre-plant "burndown", pre-plant, at-plant, or preemergence. The labels for XtendiMax and Engenia also allow for an additional 2 over-the-top post-emergence applications (in-crop) at 0.5 lbs a.e./A, whereas the Tavium label is restricted to only a single over-the-top post emergence application of 0.5 lbs a.e./A. The maximum annual application, from the labeled products and inclusive of other applied dicamba products, is not to exceed an annual maximum of 2.0 lb a.e./acre.

The products are for use on dicamba-tolerant soybean and cotton only in the following states:

Alabama, Arizona, Arkansas, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin..

Each of the product labels include the following application requirements to address spray drift, volatile emissions or runoff from the application of the products:

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- Spray drift
  - Application equipment must use spray nozzles and pressure settings from an approved equipment list maintained at www.engeniatankmix.com, https://www.syngenta-us.com/herbicides/tavium-tank-mixes , or www.XtendiMaxapplicationrequirements.com, product dependent.
  - XtendiMax® With VaporGrip® Technology must be mixed in solution with an approved drift reduction adjuvant as specified on the approved list maintained at www.XtendiMaxapplicationrequirements.com.
  - Tavium requires that an approved drift reduction agent (DRA) must also be included in the spray solution, unless otherwise indicated on www.TaviumTankMix.com.
  - Use only approved tank-mix partners from a list maintained at www.engeniatankmix.com, https://www.syngenta-us.com/herbicides/tavium-tank-mixes, or www.XtendiMaxapplicationrequirements.com , product dependent.
  - Application is only allowed by ground spray equipment and with a maximum spray boom height of 24 inches above pest or crop canopy
  - Application can only occur when boom-height wind speed is between 3 and 10 miles per hour.
  - DO NOT spray during an inversion; only spray between one hour after sunrise and two hours before sunset.
  - Each product label requires a downwind 240-foot in-field spray drift setback (buffer) for all application sites
  - Each product label requires a downwind 310-foot in-field spray drift setback (buffer) for all application sites in identified counties with listed species.
- Volatile Emissions
  - XtendiMax® With VaporGrip® Technology must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.XtendiMaxapplicationrequirements.com.
  - Engenia® herbicide must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at www.engeniatankmix.com.
  - Tavium® herbicide must be mixed in solution with an approved volatility reduction adjuvant as specified on the list maintained at http://www.syngenta-us.com/herbicides/tavium-tank-mixes.
  - Application of products to soybean are prohibited after June 30 or the soybean R1 growth stage.
  - Application of products to cotton are prohibited after July 30.
  - Each product label requires a 57-foot in-field, omni-directional, volatile drift setback (buffer) in identified counties with listed species.
- Runoff
  - DO NOT apply if soil is saturated with water or when rainfall that may exceed soil field capacity is forecasted to occur within 24-48 hours.
  - Under some conditions, dicamba has the potential for runoff several days after application. Poorly draining, wet, or erodible soils with readily visible slopes are more prone to produce runoff. When used on erodible soils or where adjacent to sensitive areas, best management practices for minimizing runoff should be employed.

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Table 2.1. Counties with Additional Spray Drift Controls and Volatile Emissions Controls (310 ft downwind spray drift & 57 ft omnidirectional volatility setbacks), or Dicamba Product Prohibition

State	Counties that require in-field 310 ft Downwind Spray Drift & 57 ft Omnidirectional Volatile Emissions Setbacks*	Counties Prohibited for Dicamba Product Use
Alabama	DeKalb, Cherokee, Colbert, Marshall, Sumter, Jackson, Baldwin, Autauga, St. Clair, Cullman, Dallas, Madison, Calhoun, Lawrence, Morgan, Franklin, Elmore, Etowah, Chilton	N/A
Arizona	Yuma, Greenlee, Graham	N/A
Arkansas	Jefferson, Pulaski, Drew	N/A
Florida	Calhoun, Bay, Jackson, Washington, Gadsden	Palm Beach
Georgia	Floyd, Gordon, Bartow, Burke, Worth, Walker, Seminole, Decatur, Mitchell	N/A
Illinois	Bureau, Effingham, Fulton, St. Clair, Schuyler, Kankakee, Livingston, Grundy, Greene, Pike, Fayette, Tazewell, LaSalle, Morgan, Marion, Will, Madison, Peoria	N/A
Indiana	Lake, Posey, Porter, Greene, LaGrange, Harrison	N/A
Iowa	Kossuth, Howard, Hancock, Dubuque, Jackson, Dickinson, Clayton, Delaware, Emmet, Osceola, Cerro Gordo, Allamakee	N/A
Kentucky	Harrison, Bourbon, Bulitt, Warren, Henry, Jefferson, Hardin, Barren, Franklin, Fleming, Meade, Nicholas	N/A
Louisiana	Caldwell, Caddo	N/A
Michigan	Newaygo, Van Buren, St. Joseph, Ottawa, Barry, Jackson, Berrien, Washtenaw, Presque Isle, Huron, Ionia, Kent, Montcalm, Monroe, Kalamazoo, Cass, Branch, Allegan	N/A
Minnesota	Fillmore, Pope, Olmsted, Clay, Winoa, Lincoln, Murray, Pipestone, Mahnomen, Polk	N/A
Mississippi	Monroe, Prentiss, Noxubee, Itawamba	N/A
Missouri	Henry, Lawrence, Pike, Franklin, Jasper, Lincoln, Cape Girardeau, Dade, St. Clair, Dunklin	N/A
Nebraska	Lancaster, Phelps, Kearney, Custer, Gosper, Saunders, Buffalo	N/A
New Jersey	Salem	N/A
New Mexico	Doña Ana, Eddy, Chaves	N/A
New York	Madison, Genesee, Onondaga	N/A
North Carolina	Davidson, Franklin, Robeson, Lincoln, Caldwell, Randolph, Beaufort, Rowan, Cumberland, Hoke, Cabarrus, Stokes, Alexander, Sampson, Cleveland, Forsyth, Granville, Lenoir, Rutherford, Anson, Orange, Craven, Wilson, Guilford, Iredell, Harnett, Bladen, Catawba, Hyde, Gaston, Johnston, Stanly, Pender, Union, Onslow, Burke, McDowell, Wake, Buncombe, Rockingham, Henderson, Nash, Brunswick, Surry, Columbus	N/A
North Dakota	Sargent, Ward, Bottineau, McHenry, McLean, Richland, Stutsman	N/A
Ohio	Portage, Ottawa, Erie	N/A
Oklahoma	Osage	N/A

State	Counties that require in-field 310 ft Downwind Spray Drift & 57 ft Omnidirectional Volatile Emissions Setbacks*	Counties Prohibited for Dicamba Product Use
South Carolina	Williamsburg, Darlington, Aiken, Lexington, Greenville, Florence, Orangeburg, Spartanburg, Edgefield, Horry, Lancaster, Allendale, Clarendon, Richland, Barnwell	N/A
South Dakota	Deuel, Clark, Brown, Codington, Roberts, Brookings, Hamlin, Day, Grant, Marshall	N/A
Tennessee	Marion, White, Rutherford, Grundy, Bedford, Montgomery, Davidson, Bledsoe, Polk, McNairy, Fentress, Franklin, Cheatham, Madison, Maury	Wilson
Texas	Refugio, Hidalgo, Ford Bend, Kleberg, Hays, Medina, Willacy, Harris, Mitchell, Coke, Nueces, Runnels, Uvalde, Starr, El Paso, Robertson, Cameron, Jim Wells	N/A
Virginia	Dinwiddie, Mecklenburg	N/A
Wisconsin	Sauk, Dunn, Jackson, Green Lake, Vernon, Waushara, Waupaca, Sheboygan, Portage, Eau Claire, Oconto, Adams, Barron, Monroe, Shawano, Dane, Chippewa, Marquette, Richland, Wood, Grant, Columbia, Clark, St. Croix, Juneau, Manitowoc	N/A

*The percentage of soybean and cotton acres in these select counties are 13 and 15 percent, respectively. On a state level, most are impacted at 1% or less. The range of percent of crop impacted in a state is 0 to 3% for soybeans and 0 to 5% for cotton[17]

2.3.3. Determining How Far Off-Field Effects are Reasonably Expected to Occur.

The action area extends from the pesticide use site to the furthest distance at which effects on listed species or designated critical habitat are reasonably expected to occur. EPA determines the action area using the labeling, including the mandatory control measures for use of the product. Referring to the conservative screening-level assessment in **Section 1,** non-monocot plants are the most sensitive directly affected taxa, and EPA used distances to effects for them to establish the boundary of the action area, which includes plant-mediated indirect effects on other taxa. With a sensitive taxa established, EPA then determined the furthest distance off field where effects to non-monocot plants might occur, given the label control measures for off-field movements of dicamba (spray drift, volatile drift, and runoff) and by counties in the 34 state registration area for dicamba product use on DT-soybean and cotton fields.

EPA evaluated control measures against the following criteria:

- reasonable expectation of no discernable effect to species or habitat
- address effects as they quantitatively relate to growth, survival, and reproduction
- Use of at least 95% certainty of avoiding effects on listed species for all combined mitigation options

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[17] For soybeans, IL is 3%, SD is 2%, remainder are 1% or less. For cotton, TX is 5%; SC, NC, and GA are 2%; remainder are 1% or less.

- consideration of incident Information
- mitigation for any wide area effects

EPA employed the following methodology in evaluating the use of the product as set out on the labels. First, while each requirement on the labels has some probability of failure, whether the action may affect listed species or their designated critical habitat involves an analysis of the label requirements as a whole (i.e., the combined control measures intended to control off site movement (volatility or spray drift)). EPA determined that no more than 5% failure for the combined safety measures (i.e., > 95% certainty) was the appropriate level at which no discernible effects are reasonably expected to occur to listed species or their designated critical habitat.

EPA first considered the requirements and restrictions on the labels to determine the action area, including determining how far the product moves from the treatment area. That distance informs whether there are any discernible effects to listed species or their designated habitat. **Section 2.2.1.1** summarizes the label requirements and local requirements applicable in the 34 states where dicamba products are registered for use on DT-soybeans or cotton.

Appendix F presents the protection probabilities associated with a range of in-field downwind spray drift setbacks. As labeled, the majority of counties have an in-field 240-foot setback. The distance to the endangered species threshold for non-monocot plants is 310 feet (**Section 1.7**). With the source of dicamba moved into the field 240 feet there still remains an area potentially affected 70 feet off-field (310-240 = 70 feet). In all counties except those identified in **Table 2.1**, the action area includes the treated cotton or soybean field and an additional 70 feet off-field. However, there are 287 counties with a 310 foot in-field spray drift setback. In these 287 counties, the movement of the dicamba source further in-field limits the action area to the treated field border. See **Section 1.7** for additional discussion regarding endpoints.

EPA then considered the labeling restrictions addressing the potential for volatile emissions. **Appendix J** presents the analysis of the consideration of all the restrictions to control volatile emissions (VRAs, application cut-off dates, and an in-field 57-ft omnidirectional application setback). These combined control measures result in a better than 95% certainty that dicamba exposures at the edge of the field are below a level where there are any discernible effects to listed plant species. Therefore, in counties where those combined control measures are in effect, the action area, once again, does not extend beyond the edge of the treated soybean or cotton field. In contrast, counties which require the VRA and application date cut-off measures, in the absence of the in-field setback, have an area of effects that extends beyond edge of the field 57 feet to reflect the absence of the in-field omnidirectional setback. Moreover, these combined volatile emissions control measures also address incidents and area wide damage discussed in **Section 1.7.10** because the requirement for a volatility reduction agent addresses off-site volatile emissions from treated fields and therefore the loading to downwind atmosphere. Similarly, the application cut off dates addresses the timing of applications that would have been allowed to occur when temperature conditions favor volatility, again reducing loading to the downwind atmosphere.

The addition of an in-field 57 ft omnidirectional volatility setback places the source of dicamba well within the boundaries of the treated field. This untreated area afforded by the setback provides an area for attenuation and infiltration of runoff which would serve to reduce the off-field transport of dicamba. This in combination with label instruction to avoid application to saturated soils, or within 48 hours of predicted rainfall events, is support for EPA's reasonable conclusion that there are no discernible effects

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off-field from runoff in the 287 counties where the 57 ft setback is required. See **Section 1.7.5** and **Appendix G** for more details on runoff.

In summation, in counties where there is an infield 240-ft downwind spray drift setback and no omnidirectional infield volatility setback (**Figure 2.2a**), the action area extends from the soybean or cotton field out to a distance of 70 feet. In the counties with listed species, and taking into account the mandatory in-field 310-ft downwind spray drift set back and the mandatory in-field 57-ft omnidirectional volatile setback, EPA determined that the action area extends only to the edge of the treated soybean or cotton field (**Figure 2.2b**). An option to use hooded sprayers in applications on soybean fields (see **Appendix O**) and a smaller spray drift setback (240 feet in select counties) will not reduce the action area that has been conservatively established using the maximum setbacks.

Figure 2.2. Visual depiction of the action area in counties without ESA protective setbacks (a) and counties with such setbacks (b)

2.3.4. Developing geographical layers for the action area (identifying areas where listed species or critical habitat overlap with the action area)

EPA conducted two steps in defining the GIS layer for the action area:

1. EPA established the footprint of cotton and soybean application sites as ESA Use Data Layers (UDLs) for the 34 states where dicamba is used on GMO cotton and soybean (AL, AZ, AR, CO, DE, FL, GA, IL, IA, IN, KS, KY, LA, MD, MI, MN, MS, MO, NE, NM, NJ, NY, NC, ND, OH, OK, PA, SC, SD, TN, TX, VA, WV, WI). These were generated by combining multiple years (2013-2017) of the Cropland Data Layer (CDL)

2. EPA then extended the UDLs outwards by 30 m (98 feet, the limit of GIS resolution) in all directions to represent the off-site distance portions of the action area (70 feet from the treated field; see **Section 2.3.3**) in those counties where there is no 310-ft or 57-ft setbacks. This is a majority of the DT cotton and soybean growing counties. In the remaining counties, those with the 310 ft and 57-ft setbacks, the edge of the cotton and soybean UDLs themselves for the boundary of the action areas because effects are not expected beyond the treated field edge with these control measures in place.

2.3.5. Determine Listed Species Ranges and Designated Critical Habitats (CH)

EPA conducted three steps in establishing species ranges and CH locations:

1. EPA consulted the known listed species and CH locations provided by the U.S Fish and Wildlife Service (USFWS), downloaded in January 2019 (USFWS 2019).
2. EPA created a list of species and critical habitats in 34 states labeled for use
3. EPA created a GIS layer of the portions of species ranges and CH's that reside within the 34 states, focusing on listed non-monocot plants, and any additional listed species identified in U.S. Fish and Wildlife Service Recovery Plans as having an obligate relationship to non-monocot plants.

2.3.6. Overlap Analysis For Listed Species and Critical Habitats

The overlap analysis phase consists of a comparison of the GIS layers for the action area and the species range and CH locations. First, species with greater than 1% overlap[1] with the action area are identified, next counties for these species with greater than 1% overlap are identified. EPA concluded that an

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[1] EPA has used this 1% overlap criteria because a known source of error within spatial datasets is positional accuracy and precision. The National Standard for Spatial Data Accuracy outlines the accepted method for calculating the horizontal accuracy of a spatial dataset (FGDC, 1998). To prevent false precision when calculating area and the percent overlap, only two significant digits should be considered for decision purposes given the reported 60 meters of horizontal accuracy for the CDL.

overlap is reasonably expected to occur for these counties with greater than 1% overlap[18] of a species range or CH with the action area.

EPA identified twenty-three listed species within the action area in the 34 states of dicamba product use that could potentially have an obligate relationship with non-monocot plants. These are the species that require a species-specific risk-based evaluation to complete an effects determination for them. These species include:

- Florida bonneted bat (*Eumops floridanus*)
- Indiana bat (*Myotis sodalis*)
- Northern long-eared bat (*Myotis septentrionalis*)
- Ozark bat (*Corynorhinus townsendii ingens*)
- Virginia big-eared bat (*Corynorhinus (=Plecotus) townsendii virginianus*)
- Gray wolf (*Canis lupis*)
- Mexican wolf (*Canis lupus baileyi*)
- Jaguar *(Panthera onca)*
- Gulf-coast jaguarundi (*Herpailurus (=Felis) yagouaroundi cacomitli*)
- Ocelot (*Leopardus (Felis) pardalis*)
- Sonoran pronghorn antelope *(Antilocapra americana sonoriensis)*
- Whooping crane (*Grus americana*)
- Attwater's greater prairie-chicken (*Tympanuchus cupido attwateri*)
- Eskimo curlew (*Numenius borealis*)
- Gunnison sage grouse (*Centrocercus minimus*)
- Mississippi sandhill crane (*Grus canadensis pulla*)
- California condor (*Gymnogyps californianus*)
- Eastern Massasauga rattlesnake (*Sistrurus catenatus*)
- Indigo snake (*Drymarchon corais couperi*)
- Gopher tortoise (*Gopherus polyphemus*)
- Houston toad (*Bufo houstonensis)*
- American burying beetle (*Nicrophorus americanus*)
- Rusty patch bumble bee (*Bombus affinis*)

The only CH overlapping the action area is for the whooping crane and a more refined analysis is necessary to complete an effects determination (**Section 2.2.5**)

All other species and CH within the 34 states of dicamba product use are outside the action area. EPA concludes these listed species and CH are unaffected by this federal action, therefore the Agency does

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[18] EPA has used this 1% overlap criteria because a known source of error within spatial datasets is positional accuracy and precision. The National Standard for Spatial Data Accuracy outlines the accepted method for calculating the horizontal accuracy of a spatial dataset (FGDC, 1998). To prevent false precision when calculating area and the percent overlap, only two significant digits should be considered for decision purposes given the reported 60 meters of horizontal accuracy for the CDL.

not need to make effect determinations for all of the species outside the action area. For example, the Karner blue butterfly *(Lycaeides melissa samuelis)* range occurs within some of the 34 states registered for use. This species has an obligate relationship with wild lupines (*Lupinus perennis*) upon which the adults lay eggs and the larvae develop. However, the species range does not overlap with the action area, and so an effects determination is not needed for a species outside the action area.

2.3.6.1. Uncertainties Associated with the Overlap Analysis

EPA based the overlap analysis on the species locations provided by the US Fish and Wildlife Service (USFWS, 2019). Species range is defined as the geographical area where a species could be found in its lifetime. Produced and managed by the species experts in the agencies responsible for implementing the Endangered Species Act (ESA), these data are the best available information for species range. EPA acknowledges that even though these are the best available data, there are several uncertainties. The range information is not sub-divided into additional qualifiers such as current/historical locations or temporal information to account for distribution variations relating to timing such as seasons. Without additional distribution information, EPA applies certain additional conservatisms: specifically, a uniform distribution within the range is assumed, meaning the species is assumed to be present in all sections of the range at all times of the year. This assumption is an additional conservatism because this distribution is unlikely to actually occur based a species life history.

Other commonly known and related sources of uncertainty for GIS data generally relate to accuracy and precision. Accuracy can be defined as how well information on a map matches the values in the real world. Precision relates to how well the description of the data used for mapping matches reality, based on closeness of repeated sets of measurements. The more precise the data, the more likely additional measurement or calculation will show the same result. Some sources of inaccuracy and imprecision in GIS data are obvious while others are difficult to identify. It is important to consider these sources of error as GIS software can make it appear that data are accurate and precise beyond the limits of the data. When conducting this spatial analysis to assess the relationship between the species range and agricultural location, EPA made conservative assumptions related to the accuracy and precision of the available data (*e.g.*, using a 30 m resolution for the overlap process). These assumptions impact the uncertainty of the relationship, and generally overestimate the relationship between of species range and agricultural locations.

To address classification accuracy and positional accuracy of the agricultural GIS data used, EPA combined multiple years into a Use Data Layer (UDL) for each crop to represent anywhere the crop could be found. This is likely an overestimate of where a crop is found in any given year due to common agricultural practices such as rotation. Data resolution, or the smallest difference between features that could be recorded, is related to accuracy. The raster land cover data used to identify agricultural land, the Cropland data layer (CDL) produced by United States Department of Agriculture (USDA), has a resolution of 30 meters. A raster data set can be re-sampled into smaller increments, but this does not improve the resolution or accuracy of the dataset. For this reason, values cannot be established with a higher level of resolution than 30 meters, values that are not multiples of 30 cannot be determined (*e.g.*30, 60, 90 are distance in the dataset; 50 is not).

Precision errors can be introduced when formatting data for processing. Formatting changes can include changes to scale, reprojections of data, and data format conversions (raster to vector or vice versa). Sources of errors that are not as obvious can include those originating from the initial measurements, digitizing of data, and using different versions of a dataset. These types of precision

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error may introduce edge effect, or misaligned dataset when conducting the spatial analysis. Borders following the general shape of the county boundaries but do not align exactly with range information used could be result of this type of precision error.

These uncertainties impact the relationship between the agricultural areas and species locations. EPA's spatial analysis makes conservative assumptions to err on the side of overestimating the potential for species exposure when assessing the relationship of the species range to agricultural land. EPA uses 5 years of crop information in constructing the UDLs representing the agricultural land, so that the UDLs include every location where the crop was grown during those 5-years. Due to normal agricultural practices, this is more land than expected in a given year. The relationship between the species and the agricultural land may be overestimated when the range is larger than the actual area occupied and the additional area includes agricultural use or where edge effects were introduced. When considering the species location data, all areas are conservatively assumed to be occupied at the time the pesticide is used. County or state boundaries can be used as a conservative estimate for species range but species and natural habitats are not expected to follow man-made boundaries. When the species locations have not been refined beyond these man-made boundaries, underestimates of the relationship between species range and agricultural use can occur. While this underestimation is possible, EPA makes several conservative assumptions for agricultural land and species life history to account for this possibility. For agricultural land, use of the UDLs representing multiple years of agriculture, expands the agricultural footprint beyond what is expected in a given year. For species life history, EPA assumes all areas of the species range are occupied at the time of treatment. In addition to these assumptions, EPA uses the best available species location information from the species experts at USFWS, minimizing this possibility.

2.3.7. Risk-based Species-Specific Analysis

EPA evaluated species-specific biological information (e.g., body size, dietary requirements, and seasonality) and the labeled dicamba use patterns in more depth to further refine a risk-based assessment for the 23 listed species found to be within the action area. EPA determined dicamba exposure values from the upper bound of the modeled T-REX run for exposures following spray applications based on the Kenaga nomogram modified by Fletcher *et al* (1984), which is based on a large set of actual field residue data.

Similar modeling of DCSA residues, which are formed inside the tolerant-soybean and tolerant-cotton plants through plant metabolism, is not feasible at this time due to a lack of sufficient data tracking DCSA residues in plant tissues over time to ascertain degradation rates. Therefore, EPA used the maximum empirical measured DCSA residue concentrations in dicamba-tolerant soybean (61.1 mg/kg DCSA in broadleaf plants and 0.440 mg/kg in soybean seeds) to evaluate chronic exposures to DCSA for birds and mammals foraging on sprayed DT-soybean plants. As noted previously in **Section 1.6**, chronic exposures to DCSA in cotton plants did not result in risk to any taxa (due to lower maximum residue loads compared to soybean). EPA assumed residues in arthropods (as a dietary item for birds and mammals consuming insects that have consumed soybean tissues with DCSA residues) to follow the Kenaga nomogram relationship between broadleaf plants and arthropods for spray applications (*i.e.* arthropod concentrations estimated to be approximately 70% of the concentrations in broadleaf plant tissues or 42.5 ppm DCSA in arthropods feeding on soybean plants, see **Section 1** for further description of this analysis).

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The following discusses the lines of evidence and processes that EPA used to make effects determinations for listed species within the action area and either 1) from taxa that were determined to need further review for direct effects (**Section 1**) or 2) species with an obligate dependency on the most sensitive taxa (non-monocot plants).

2.3.7.1. Effects determination assessment for the listed species that overlap with the action area

EPA evaluated additional lines of species-specific evidence for the 23 listed species noted above that are on the treated field. In the example, EPA's refined assessment might investigate the impacts of more specific species data related to:

1. Body size (e.g., species is larger than the body size used in the initial screen)
2. Food consumption tailored to:
   a. The true weight of the animal and
   b. Energy requirements of the animal and associated changes to the food intake model
3. Toxicity endpoints were scaled from the weight of the tested surrogate species to reflect the comparatively larger actual size of the animal, where appropriate.

2.3.7.2. Listed Bird Species on Treated-Fields

The screening-level assessment indicated that birds could be at risk of mortality from acute exposures to dicamba on treated fields, but chronic risk to parent dicamba was not expected as no chronic RQs exceeded the Agency's LOC (1.0) for chronic risk (**Section 1**). However, the screening-level risk assessment found that chronic exposures to DCSA residues in soybean could be a concern, while exposures in cotton would not exceed the Agency's LOC for chronic risk. Therefore, a species-specific assessment and effects determinations for listed species was necessary. The species-specific assessment and effects determinations examined where potential effects could reasonably be expected to occur on treated soybean and cotton fields. EPA conducted this refined assessment for acute (dicamba only) and chronic (DCSA only, and only for soybean) exposures to make effects determinations for these listed species. EPA identified six listed bird species as overlapping with the action area - these are reasonably expected to occur on treated soybean and cotton fields. Therefore, EPA evaluated species-specific biological information and dicamba use patterns in more depth to further refine the assessment and effects determinations for the seven species.

2.3.7.2.1. Attwater's greater prairie-chicken

Dicamba Acute Effects Assessment

Attwater's prairie chickens are omnivorous, feeding on a variety of dietary items including seeds and pods, insects, broadleaf plants and grasses, with adults feeding primarily on grain, while juvenile

chickens primarily consume insects. (Lehman, 1941). Given the shifting dietary consumption patterns for prairie chickens throughout the year, EPA considered two potential exposure windows from dicamba applications:

1. An earlier spring application window where the chicken's diet is dominated by plant matter. This exposure window evaluates the impact following two pre-emergent applications at the maximum rate (0.5 lbs ae/A; 7-day retreatment) and the prairie chickens diet consists of seeds/waste grain (59%), broadleaf plants (35%) and insects (6%) based on Lehman, 1941.
2. A later spring/summer application window where the chicken's diet shifts to be more omnivorous. This exposure window evaluates the impact following two pre-emergent and two post-emergent applications at the maximum rates (0.5 lbs ae/A; 7-day retreatment intervals) and the prairie chickens diet consists of seeds (45%), insects (29%) and broadleaf plants (26%) based on Lehman, 1941.

As a conservative approach, EPA used a weighted average of the modeled upper bound T-REX residues for each dietary item to evaluate the potential risk posed by dicamba applications during these exposure windows. This is considered a conservative approach as 100% of the chicken's diet would be considered to consist of exposed dietary items receiving the upper bound Kenaga nomogram dicamba residues from the spray application. A biologically representative assessment follows for each exposure window:

1) *Early Spring Exposure Window*
   Field metabolic rate kcal/day = $1.146(772)^{0.749}$ = 166.73 kcal/day
   (USEPA 1993, body weight reflects screening assumption for the Attwater's greater prairie-chicken from US FWS Recovery Plan (USFWS, 2010);
   http://ecos.fws.gov/docs/recovery_plan/100426.pdf)
   Spring Chicken's dietary fractions: 6% insects, 59% seeds, 35% broadleaves (Lehman, 1941)
   Weighted average caloric content of diet:
   0.06 (% insect diet)*1.67 kcal/g (energy content of insect prey from USEPA, 1993)*0.72 (assimilation efficiency from USEPA, 1993) +
   0.59 (% seed diet)*4.63 kcal/g (energy content of seeds; USEPA, 1993)*0.59 (seeds Assimilation Efficiency, USEPA, 1993) +
   0.35 (% broadleaf plant diet)*0.088 kcal/g (energy content of broadleaf plant diet; USEPA, 1993)*0.47 (assimilation efficiency, USEPA, 1993)
   =0.072 + 1.61 +0.014 = 1.7 weighted average diet energy kcal/g

   Mass of diet consumed per day = 166.73 kcal/day/(1.7 weighted average kcal/g ww = 98.1 g/day

   Concentration of dicamba in dietary items for 2 pre-emergent dicamba applications: 73.38 mg/kg-ww (insects), 11.71 mg/kg-ww (seeds), 105.38 mg/kg (broadleaf plants) from T-REX run in **Appendix M**

   Concentration of dicamba in chicken's daily diet = 0.06 (% insect diet)*73.38 mg/kg + 0.59 (%seed diet)*11.71 mg/kg + 0.35(%broadleaf plant diet)*105.38 mg/kg *0.001 kg/g

$= (4.4 + 6.9 + 36.9)(0.001) = 0.0482$ mg/g

Mass of dicamba in diet: 98.1 g/day X 0.0482 mg/g = 4.73 mg/day

Daily dose in chicken = 4.7 mg dicamba/day/0.772= 6.13 mg/kg-bw/day

Chicken LD50 mg/kg-bw = 188 mg/kg-bw X $(772/178)^{(1.15-1)}$ = 234.28 mg/kg-bw

The RQ for acute effects = 6.13/234.28 = 0.026

An acute RQ of 0.026 does not exceed the acute LOC of 0.1 for listed species. Therefore, a "No Effects" determination would be made for pre-emergent exposures to the prairie chicken in spring.

2) *Late Spring/Summer Exposure Window*

Field metabolic rate kcal/day = $1.146(772)^{0.749}$ = 166.73 kcal/day
(USEPA 1993, body weight reflects screening assumption for the Attwater's greater prairie-chicken from US FWS Recovery Plan (USFWS, 2010);
http://ecos.fws.gov/docs/recovery_plan/100426.pdf)

Summer Chicken's dietary fractions: 29% insects, 45% seeds, 26% broadleaves (Lehman, 1941)
Weighted average caloric content of diet:
0.29 (% insect diet)*1.67 kcal/g (energy content of insect prey from USEPA, 1993)*0.72 (assimilation efficiency from USEPA, 1993) +
0.45 (% seed diet)*4.63 kcal/g (energy content of seeds; USEPA, 1993)*0.59 (seeds Assimilation Efficiency, USEPA, 1993) +
0.26 (% broadleaf plant diet)*0.088 kcal/g (energy content of broadleaf plant diet; USEPA, 1993)*0.47 (assimilation efficiency, USEPA, 1993)
=0.35 + 1.23 + 0.011 = 1.6 weighted average diet energy kcal/g

Mass of diet consumed per day = 166.73 kcal/day/(1.6 weighted average kcal/g ww = 104.9 g/day

Concentration of dicamba in dietary items for 2 pre-emergent and 2 post-emergent dicamba applications: 96.49 mg/kg-ww (insects), 15.40 mg/kg-ww (seeds), 138.58 mg/kg (broadleaf plants) from T-REX run in **Section 1.4**.

Concentration of dicamba in chicken's daily diet = 0.29 (% insect diet)*96.49 mg/kg + 0.45 (%seed diet)*15.40 mg/kg + 0.26 (%broadleaf plant diet)*138.58 mg/kg *0.001 kg/g
= (27.99 + 6.93 +36.04)(0.001) = 0.071 mg/g

Mass of dicamba in diet: 104.9 g/day X 0.071 mg/g = 7.44 mg/day

Daily dose in chicken = 7.44 mg dicamba/day/0.772= 9.64 mg/kg-bw/day

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Chicken LD50 mg/kg-bw = 188 mg/kg-bw X $(772/178)^{(1.15-1)}$ = 234.28 mg/kg-bw

The RQ for acute effects = 964/234.28 = 0.041

An acute RQ of 0.041 does not exceed the acute LOC of 0.1 for listed species. Therefore, a "No Effects" determination would be made for the prairie chicken exposed to later spring/summer applications.

DCSA Assessment for Attwater's Greater Prairie Chicken Consuming Exposed Dietary Items in Soybean Fields

A DCSA assessment was not conducted for plants emerging in the field at the time of pre-emergent applications because those plants would be weed species that do not contain the genes to convert dicamba to the DCSA.

EPA therefore considered the potential exposures to DCSA for the chicken by considering the late exposure window as described above except that the maximum DCSA residues observed in soybean forage/hay (61.1 mg/kg) and seed tissue (0.440 mg/kg) as described in **Section 1.4** are used in place of the T-REX dicamba estimates. DCSA residues in arthropods are assumed to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the insect prey base (**Section 1.4**). This is considered a conservative approach as 100% of the chicken's diet would be considered to consist of exposed dicamba-tolerant soybean plants that had the highest measured DCSA residues and arthropods that fed exclusively on those plants. A biologically representative assessment follows:

Field metabolic rate kcal/day = $1.146(772)^{0.749}$ = 166.73 kcal/day
(USEPA 1993, body weight reflects screening assumption for the Attwater's greater prairie-chicken from US FWS Recovery Plan (USFWS, 2010); http://ecos.fws.gov/docs/recovery_plan/100426.pdf)

Summer Chicken's dietary fractions: 29% insects, 45% seeds, 26% broadleaves (Lehman, 1941)
Weighted average caloric content of diet:
0.29 (% insect diet)*1.67 kcal/g (energy content of insect prey from USEPA, 1993)*0.72 (assimilation efficiency from USEPA, 1993) +
0.45 (% seed diet)*4.63 kcal/g (energy content of seeds; USEPA, 1993)*0.59 (seeds Assimilation Efficiency, USEPA, 1993) +
0.26 (% broadleaf plant diet)*0.088 kcal/g (energy content of broadleaf plant diet; USEPA, 1993)*0.47 (assimilation efficiency, USEPA, 1993)
=0.35 + 1.23 + 0.011 = 1.6 weighted average diet energy kcal/g

Mass of diet consumed per day = 166.73 kcal/day/(1.6 weighted average kcal/g ww = 104.9 g/day

Concentration of DCSA in dietary items (from **Section 1.4**): soybean forage/hay (61.1 mg/kg), soybean grain (0.440 mg/kg), exposed arthropod prey (42.5 mg/kg)

Concentration of DCSA in chicken's daily diet = 0.29 (% insect diet)*42.5 mg/kg + 0.45 (%seed diet)*0.44 mg/kg + 0.26 (%broadleaf plant diet)*61.1 mg/kg *0.001 kg/g
= (12.3 + 0.198 + 15.89)(0.001) = 0.028 mg/g

Mass of DCSA in diet: 104.9 g/day X 0.028 mg/g = 2.98 mg/day

Daily dose in chicken = 2.98 mg DCSA/day/0.772= 3.86 mg/kg-bw/day

RQ for chronic DCSA effects = 3.86/40.9 = 0.09

A chronic RQ of 0.09 does not exceed the chronic LOC of 1.0 for listed species. Therefore, a "No Effects" determination would be made for the prairie chicken.

2.3.7.2.2. California Condor

The species' 5-Year review (USFWS, 2013a; https://ecos.fws.gov/docs/five_year_review/doc4163.pdf) describes the condor as an obligate scavenger feeding primarily on large mammalian carcasses including deer, elk, feral pigs, livestock, horses, and pinnipeds, though smaller carrion may also be consumed. The assessment here accounts for the condor's biology:

The first step is to calculate dicamba DGA residues in the prey species. Using the conservative assumptions that the prey species is represented by a 1000 g mammal that feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba, EPA calculated the residues in this prey as 38 mg dicamba ae/kg-bw (T-REX modeling from screening level risk assessment in **Section 1**).

The next step is to calculate the expected daily dose for a typical 10 kg (10000 g, Dunning 1984) condor, the adjusted LD_{50} value, and the acute dose-based RQ for the condor based on the following allometric equations:

Dicamba Acute Effects Assessment

Food Intake (wet) = $(0.301(10000)^{0.75})/(1-0.69)/1000$ = 0.97 kg wet/day
Dose-based EEC in condor eating large mammal= 38 mg/kg wet x 0.97/(10000/1000) = 3.69 mg/kg-bw/day
Adjusted LD_{50} = 188 mg/kg-bw $(10000/178)^{(1.15-1)}$ = 344 mg/kw-bw
Acute Dose-Based RQ = 3.69/344 = 0.01

An acute RQ of 0.01 does not exceed the LOC of 0.1 for listed species. Consequently, as it relates to the parent dicamba effects determination, EPA concludes "no effect" for the California condor.

The first step is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EPA calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day
1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day
DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = 9.34 mg/kg-bw/day

The next step is to calculate the expected daily dose for a typical 10 kg (10000 g, Dunning 1984) condor, the adjusted LD_{50} value, and the acute dose-based RQ for the condor based on the following allometric equations:

Food Intake (wet) = $(0.301(10000)^{0.75})$/(1-0.69)/1000 = 0.97 kg wet/day
Dose-based EEC in condor eating large mammal= 9.34 mg/kg wet x 0.97/(10000/1000) = 0.91 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

Chronic Dose-Based RQ = 0.91/40.88 = 0.02

A chronic RQ of 0.02 does not exceed the chronic LOC of 1.0 for listed species, therefore as it relates to DCSA effects determination, EPA concludes "no effect" for the California condor.

EPA makes a "no effect" determination for the California condor.

2.3.7.2.3. Gunnison Sage Grouse

The November 20, 2014 designation of critical habitat document for the Gunnison sage grouse (https://www.gpo.gov/fdsys/pkg/FR-2014-11-20/pdf/2014-27113.pdf, USFWS, 2014) indicates that this bird will consume a mixture of vegetable and animal matter and the crop of the bird is too weak for seed consumption. This is likely seasonally dependent being composed of nearly 100 percent sagebrush in the winter, and forbs and insects as well as sagebrush in the remainder of the year. Insect consumption may coincide with the time period associated with application of dicamba. Based on this information, it is reasonable to conclude that the sage grouse may be exposed to dicamba residues in insect prey items on crop fields, therefore EPA conducted the following species-specific analysis for the sage grouse.

Dicamba Acute Effects Assessment

Using the conservative assumption that the grouse's diet consists entirely of insects having been exposed to the upper bound Kenaga residues from the spray application of dicamba, exposure

assumptions and risk calculations were adjusted to account for the species' biology (namely body weight and food ingestion rate) and body weight specific adjusted toxicity endpoint.

Field metabolic rate kcal/day = $1.146(2400)^{0.749}$ = 389.9 kcal/day
(USEPA 1993, body weight reflects mean for the bird from Dunning (1984)

Mass of prey consumed per day = 389.9 kcal/day/(1.7 kcal/g-ww X 0.72 AE) = 318.5 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from USEPA 1993, assumption of insect prey USFWS 1983)

Mass of dicamba in insect diet = 96 mg/kg-ww from T-REX run
Mass of dicamba in daily diet = 318.5 g/day X 96 mg dicamba DGA/kg-ww insect prey X 0.001 = 30.6 mg/day

Daily dose in bird = 30.6 mg dicamba/day/2.4 = 12.7 mg/kg-bw/day
Grouse LD50 mg/kg-bw = 188 mg/kg-bw X $(2400/178)^{(1.15-1)}$ = 277.7 mg/kg-bw

The RQ for acute effects = 12.7/277.7 = 0.05

An acute RQ of 0.05 does not exceed the acute LOC of 0.1 for listed species. Further, if the diet was composed of a forb such as the treated crop plants (*i.e.* broadleaf plants), the T-REX run described in Section 1.4 would place the dicamba residue at 140 mg/kg instead of 96 mg/kg (from insect prey), resulting in a slight increase in the RQ for the bird to 0.07, which is still below the LOC of 0.1. Consequently, a "no effect" determination is made for the Gunnison sage grouse as it relates to the parent dicamba.

DCSA Chronic Effects Assessment for Gunnison Sage Grouse Consuming Prey that had Previously Consumed Soybean Forage

EPA considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as 100% of the grouse's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. A biologically representative assessment follows.

Field metabolic rate kcal/day = $1.146(2400)^{0.749}$ = 389.9 kcal/day
  (USEPA 1993, body weight reflects mean for the bird from Dunning (1984)

Mass of prey consumed per day = 389.9 kcal/day/(1.7 kcal/g-ww X 0.72 AE) = 318.5 g/day
        (1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from
        USEPA 1993, assumption of insect prey USFWS 1983)

Mass of DCSA in daily diet = 318.5 X 42.5 X 0.001 = 13.5 mg/day
Daily dose in grouse = 13.5 mg DCSA/day/2.4 = 5.6 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

RQ for chronic exposure: RQ = 5.6/40.88 = 0.14

An RQ of 0.14 does not exceed the chronic LOC of 1.0 for listed species. Further, if the diet was composed of a forb such as the treated crop plants (*i.e.* broadleaf plants), and considered to contain the maximum measured DCSA residues in soybean forage (61.1 mg/kg), the RQ would rise to approximately 0.20, which is still below the chronic LOC of 1.0 for listed species. Consequently a "no effect" determination is concluded for the Gunnison sage grouse as it relates to DCSA.

EPA makes a no effect determination for the Gunnison sage grouse.

2.3.7.2.4. Whooping crane

Whooping cranes migrate from Texas to Canada from March 25th to May 1st (Canadian Wildlife Service and USFWS, 2007; https://ecos.fws.gov/docs/recovery_plan/070604_v4.pdf). Whooping cranes are omnivorous and during migration may feed on a variety of foods including frogs, fish, plant tubers, crayfish, insects and agricultural grains. EPA considered the upper bound T-REX predicted concentrations of DGA expected to be found on arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as modeled residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods receiving the upper bound Kenaga nomogram dicamba residues from the spray application. Alternative terrestrial vertebrate prey and agricultural grains are expected to have lower residues than those predicted for arthropods. A biologically representative assessment follows:

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $1.146(5826)^{0.749}$ = 757.6 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 757.6 kcal/day/(1.7 kcal/gX0.72 AE) = 619 g/day

Mass of dicamba in insect diet 96 mg/kg-bw from T-REX run

Mass of dicamba in daily diet mg = 619 g/day X 96 mg DGA/kg bird prey X 0.001 = 59.7 mg/day

Daily dose in crane = 59.7 mg /day/5.826 kg = 10.3 mg/kg-bw/day

Scaling the acute toxicity endpoint by bodyweight (per T-REX methodology), the acute oral toxicity value for the crane is:

Crane LD50 mg/kg-bw = 188 mg/kg-bw $(5826/178)^{(1.15-1)}$ = 317.25mg/kg-bw

RQ for daily acute exposure for three applications, peak exposure number: RQ = 10.94/317.25 = 0.03.

An RQ of 0.03 does not exceed the acute LOC of 0.1 for listed species. Consequently a "no effect" determination is concluded as to the parent dicamba for the whooping crane.

DCSA Assessment for Whooping Crane Consuming Prey that had Previously Consumed Soybean Forage

EPA considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as the estimated residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. Alternative terrestrial vertebrate prey and agricultural grains are expected to have lower residues than those predicted for arthropods. A biologically representative assessment follows:

Field metabolic rate kcal/day = $1.146(5826)^{0.749}$ = 757.6 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 757.6 kcal/day/(1.7 kcal/gX0.72 AE) = 619 g/day

Mass of DCSA in insect diet 42.5 mg/kg-bw (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet mg = 619 g/day X 42.5 mg DCSA/kg bird prey X 0.001 = 26.31 mg/day

Daily dose in crane = 26.31 mg DCSA/day/5.826 kg = 4.52 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

RQ for chronic exposure: RQ = 4.52/40.88 = 0.11

An RQ of 0.11 does not exceed the chronic LOC of 1.0 for listed species. As neither DCSA nor parent dicamba have RQs above the LOC for listed species, a "no effect" determination is concluded for the whooping crane.

2.3.7.2.5. Mississippi sandhill crane

Sandhill cranes are known to feed on farm areas (USFWS, 2019b; https://ecos.fws.gov/docs/five_year_review/doc6122.pdf). Cranes feed on adult and larval insects, earthworms, crayfish, small reptiles, amphibians, roots, tubers, seeds, nuts, fruits and leaves. EPA considered the upper bound T-REX predicted concentrations of dicamba expected to be found on arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as modeled residues in arthropods are higher than for the other likely dietary items and 100% of the

crane's diet would be considered to consist of exposed arthropods receiving the upper bound Kenaga nomogram dicamba residues from the spray application. Alternative terrestrial vertebrate prey are expected to have lower residues than those predicted for arthropods. A biologically representative assessment follows:

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $1.146(2500)^{0.749}$ = 402.01 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 402.01 kcal/day/(1.7 kcal/gX0.72 AE) = 328.44 g/day

Mass of dicamba in insect diet 96 mg/kg-ww from T-REX run

Mass of DGA in daily diet mg = 328.44 g/day X 96 mg DGA/kg bird prey X 0.001 = 31.7 mg/day

Daily dose in crane = 31.7 mg DGA/day/2.5 kg = 12.7 mg/kg-bw/day

Scaling the acute toxicity endpoint by bodyweight (per T-REX methodology), the acute oral toxicity value for the crane is:

Crane LD50 mg/kg-bw = 188 mg/kg-bw $(2500/178)^{(1.15-1)}$ = 279.44 mg/kg-bw

RQ for daily acute exposure for three applications, peak exposure number: RQ = 12.7/279.44 = 0.05.

An RQ of 0.05 does not exceed the acute LOC of 0.1 for listed species. Consequently a "no effect" determination is concluded for parent dicamba for the Mississippi sandhill crane.

DCSA Assessment for Mississippi Sandhill Crane Consuming Prey that had Previously Fed On Soybean Forage

EPA considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as the estimated residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. Alternative terrestrial vertebrate prey and agricultural grains are expected to have lower residues than those predicted for arthropods. A biologically representative assessment follows:

Field metabolic rate kcal/day = $1.146(2500)^{0.749}$ = 402.01 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 402.01 kcal/day/(1.7 kcal/gX0.72 AE) = 328.44 g/day

Mass of DCSA in insect diet 42.5 mg/kg-bw (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet mg = 328.44 g/day X 42.5 mg DCSA/kg bird prey X 0.001 = 13.96 mg/day

Daily dose in crane = 13.96 mg DCSA/day/2.5 kg = 5.58 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

RQ for chronic exposure: = 5.58/40.88 = 0.14.

An RQ of 0.14 does not exceed the chronic LOC of 1.0 for listed species. Consequently, a no effect as it relates to DCSA is concluded for the Mississippi sandhill crane.

EPA makes a "no effect" determination for the Mississippi sandhill crane

2.3.7.2.6. Eskimo curlew

The Eskimo curlew is a species determined to potentially occupy treated agricultural fields such as cotton and soybean fields and thus be subject to exposure to dicamba DGA on the treated field. Historically, the species' breeding grounds were in Alaska and the Northwest Territories, Canada, and it overwintered in South America (USFWS, 2016a; https://ecos.fws.gov/docs/five_year_review/doc4866.pdf). The curlew is thought to cross the Gulf of Mexico into Texas during spring migrations and prefer burned and disturbed prairie habitats and agricultural fields where it feeds primarily on grasshoppers and other insects (Gill et al., 1998, USFWS, 2016a). The assumptions in this assessment were adjusted to account for the Eskimo curlew's biology. As a conservative approach, EPA used the modeled upper bound T-REX modeled residues for arthropods to evaluate the potential risk posed by dicamba applications at this time. This is considered a conservative approach as 100% of the Eskimo curlew's diet would be considered to consist of exposed arthropods receiving the upper bound Kenaga nomogram dicamba residues from the spray application. A biologically representative assessment follows:

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $1.146(240)^{0.749}$ = 69.5 kcal/day
(USEPA 1993, body weight reflects screening assumption for the Eskimo curlew from USGS, 2014 http://www.npwrc.usgs.gov/resource/birds/curlew/identif.htm)

Mass of prey consumed per day = 69.5 kcal/day/(1.7 kcal/g ww X 0.72 AE) = 56.8 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from USEPA 1993, assumption of insect prey from USGS 2014)

Mass of dicamba in insect diet 96 mg/kg-ww from T-REX run

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Mass of dicamba in daily diet = 56.8 g/day X 96 mg dicamba DGA/kg-ww insect prey X 0.001 = 5.45 mg/day

Daily dose in curlew= 5.45 mg dicamba DGA/day/0.24= 22.7 mg/kg-bw/day

Curlew LD50 mg/kg-bw = 188 mg/kg-bw X $(240/178)^{(1.15-1)}$ = 196.6 mg/kg-bw

The RQ for acute effects = 22.7/196.6 = 0.12

An acute RQ of 0.12 exceeds the acute LOC of 0.1 for listed species.

Given the species-specific acute exceedance, it might be reasonable to expect effects if Eskimo curlews encountered treated fields. Known occurrences of the species span Galveston County in Texas and 23 counties in Nebraska: Nuckolls, Jefferson, Saline, Polk, Wayne, Pierce, Platte, Boone, Madison, Antelope, Merrick, Stanton, Fillmore, York, Seward, Clay, Cedar, Thayer, Hamilton, Nance, Knox, Colfax, and Butler. See Appendix 4 for range and land cover analysis.

However, the species by all accounts is extremely rare. The U.S. Fish and Wildlife Service summarized curlew numbers in a recent Biological Opinion (USFWS 2012a) for the rodenticide chlorophacinone:

Recent quantitative methods used to evaluate the probability of the Eskimo curlew's existence have estimated extinction dates of 1967 and 1965, respectively, with the upper bounds of 95 percent confidence intervals in 1977 and 1970 (Elphick et al. 2010, FWS 2011e). These estimates are based on the last uncontroversial record of observance, a specimen that was shot in Barbados in 1963 (FWS 2011e). From 1963 to the spring of 2009, 39 potential sightings have occurred in 22 different years (Committee on the Status of Endangered Wildlife in Canada 2009); however, the reliability of these sightings is variable, and none have been confirmed by physical evidence (FWS 2011e). If controversial records of observance are included, then the analysis estimates an extinction date of 2008 with the upper bound of 95 percent confidence interval reaching 2013 (FWS 2011e).

In the case of chlorophacinone, EPA had initially made a "likely to adversely affect" determination for the curlew based on direct acute effects. This pesticide application involved potential large geographic areas of rangeland habitat, likely more favorable to curlews than maintained agricultural fields. The conclusion of the Biological Opinion was:

Eskimo curlews are likely already extinct or at best extremely rare; thus, direct and indirect effects from Rozol exposure are so highly unlikely to occur as to be considered discountable. Therefore, the Service does not anticipate adverse effects to Eskimo curlew from use of Rozol on BTPDs. No critical habitat for the Eskimo curlew has been designated; therefore none will be affected.

It is reasonable to reach a similar conclusion with dicamba, a compound of likely lower acute toxic hazard than chlorophacinone and proposed for use on land cover more marginal for curlews than the chlorophacinone case. **Therefore, the Agency determines that the proposed labeled use of dicamba is "not likely to adversely affect" (NLAA) the Eskimo curlew because exposures are so highly unlikely to occur as to be considered discountable.**

EPA informally consulted with the U.S. Fish and Wildlife Service on the NLAA effects determination made for the Eskimo Curlew. The concurrence memo is appended in Appendix L.

DCSA Assessment for Eskimo curlew

Given the acute analysis for parent dicamba and the conclusion of a Not likely to adversely affect (NLAA) following informal consultation with the U.S. Fish and Wildlife Service, further analysis was deemed unnecessary for potential DCSA degradate effects to the curlew.

2.3.7.3. Listed reptiles and amphibians on the treated field

As described in the screening level assessment and consistent with the Overview Document (USEPA, 2004), EPA uses birds as a surrogate for reptiles and terrestrial-phase amphibians. EPA determined that a species-specific assessment is necessary for certain reptiles and terrestrial-phase amphibians that may be acutely exposed to parent dicamba on treated soybean or cotton fields or for chronic exposures to DCSA on treated soybean fields. Four listed reptiles are reasonably expected to occur on treated soybean and cotton fields. Therefore, species specific biological information and dicamba use patterns were considered in this assessment and effects determinations were made for those species.

2.3.7.3.1. Eastern Massasauga rattlesnake

The Eastern Massasauga rattlesnake is an inhabitant of open to forested wetlands and adjacent upland areas that is known to eat voles, mice, other small mammals, small birds, amphibians, and also other species of snakes (https://www.fws.gov/midwest/endangered/reptiles/eama/). Therefore, the species may reasonably be expected to occur on treated cotton and soybean fields and thus be subject to exposure to Dicamba DGA on the treated field. This snake feeds largely on small mammals, (http://mnfi.anr.msu.edu/emr/eco.cfm). Using the conservative assumptions that the prey species is represented by a 35g mammal that feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba and that the snake exclusively feeds on this prey species, exposure assumptions and risk calculations were adjusted to account for the species' biology (namely body weight and food ingestion rate) and body weight specific adjusted toxicity endpoints.

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $0.0530(350)^{0.799}$ = 5.7 kcal/day
(USEPA 1993, body weight is mean of reported values in
https://www.aboutanimals.com/reptile/massasauga-rattlesnake/).

Mass of prey consumed per day = 5.7 kcal/day/(1.7 kcal/g ww X 0.78 AE) = 4.3 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.78 is assimilation efficiency from USEPA 1993)

Mass of dicamba in a 35-g mammal diet = 160 mg/kg-ww from T-REX run (**Section 1**)
Mass of dicamba in daily diet = 4.3 g/day X 160 mg/kg-ww mammal prey X 0.001 = 0.69 mg/day

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Daily dose in rattlesnake = 0.69 mg/day dicamba DGA/0.350 = 1.97 mg/kg-bw/day

Appropriate scaling factors are not available for reptiles and amphibians so the acute toxicity value for the bobwhite quail (most sensitive avian species for which acute data are available) serves as a surrogate (USEPA, 2004) toxicity value for the rattlesnake:

Rattlesnake LD_{50} mg/kg-bw = 188 mg/kg-bw
RQ for acute effects = 1.97/188 = 0.008

An acute RQ of 0.008 does not exceed the acute listed species LOC of 0.1. Consequently, a no effect determination is concluded as it relates to parent dicamba the Eastern Massasauga rattlesnake.

DCSA Chronic Effects Assessment for Eastern Massasauga Rattlesnake Consuming Prey that had Previously Consumed Exposed Soybean Forage

As noted above, the Eastern Massasauga rattlesnake feeds largely on small mammals and also birds, amphibians and other snakes. Using the conservative assumptions that the prey species is represented by a mammal that feeds exclusively on exposed soybean plant tissue containing the maximum measured DCSA residues of 61.1 ppm and that the snake exclusively feeds on this prey species, the assumptions were adjusted to account for the rattlesnake's biology:

Field metabolic rate kcal/day = $0.0530(350)^{0.799}$ = 5.7 kcal/day
(USEPA 1993, body weight is mean of reported values in
https://www.aboutanimals.com/reptile/massasauga-rattlesnake/).

Mass of prey consumed per day = 5.7 kcal/day/(1.7 kcal/g ww X 0.78 AE) = 4.3 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.78 is assimilation efficiency from USEPA 1993)

Mass of DCSA in a mammal diet 61.1 mg/kg-ww (maximum empirical residue data on soybean forage)

Mass of DCSA in rattlesnake's daily diet = 4.3 g/day X 61.1 mg dicamba DGA/kg-ww mammal prey X 0.001 = 0.26 mg/kg-bw/day

Daily dose in rattlesnake = 0.26 mg DCSA/day/0.350 = 0.75 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck [most sensitive avian species for which chronic data are available and serves as the surrogate species for reptiles] study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

RQ for chronic exposure: RQ = 0.75/40.88 = 0.02

An RQ of 0.02 does not exceed the chronic LOC of 1.0 for listed species. Consequently, as it relates to DCSA, a "no effect" determination is concluded for the Eastern Massasauga rattlesnake.

EPA makes a "no effect" determination for the Eastern Massasauga rattlesnake.

2.3.7.3.2. Gopher tortoise

The gopher tortoise inhabits droughty, deep sand ridges, xeric communities, originally longleaf pine-scrub oak, and may also be found along fence rows, field edges, power lines, and in pastures (USFWS, 1990a; https://ecos.fws.gov/docs/recovery_plan/901226.pdf). The tortoise feeds on plant material, such as leaves and grass. EPA considers the maximum T-REX predicted concentrations of DGA expected to be found on short grass as a conservative pesticide load in the dietary items. This is considered conservative as it assumes 100% of the tortoise's diet is exposed short grass (for which modeled T-REX residues are higher than any other dietary item) receiving the upper bound Kenaga nomogram dicamba residues from the spray application. A biologically representative assessment follows:

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $0.019(4500)^{0.841}$ = 22.44 kcal/day (USEPA 1993)

Mass of soybean plants consumed per day = 22.44 kcal/day/(1.3 kcal/gX0.47 AE) = 36.73 g/day

Mass of Dicamba in short grass diet 250 mg/kg-ww from T-REX run
Mass of Dicamba in daily diet mg = 36.73 g/day X 262.94 mg DGA/kg tortoise prey X 0.001 = 9.18 mg/day

Daily dose in tortoise = 9.18 mg dicamba/day/4.5 kg = 2.0 mg/kg-bw/day

Appropriate scaling factors are not available for reptiles and amphibians so the acute toxicity value for the bobwhite quail (most sensitive avian species for which acute data are available) serves as a surrogate (USEPA, 2004) toxicity value for the tortoise:

Tortoise LD50 mg/kg-bw = 188 mg/kg-bw
RQ for daily acute exposure for three applications, peak exposure number: RQ = 2.0/188 = 0.01.

An RQ of 0.01 does not exceed the acute LOC of 0.1 for listed species. Consequently, as it relates to parent dicamba a "no effect" determination is concluded for the gopher tortoise.

DCSA Assessment for Gopher Tortoise Consuming Soybean Forage

As above, the tortoise feeds on plant material, such as leaves and grass. EPA considers the maximum measured DCSA residues in soybean tissue as a conservative pesticide load in the dietary items. This is considered conservative as it assumes 100% of the tortoise's diet is exposed soybean leaves/stems, which would have the highest DCSA residues. A biologically representative assessment follows:

Field metabolic rate kcal/day = $0.019(4500)^{0.841}$ = 22.44 kcal/day (USEPA 1993)

Mass of soybean plants consumed per day = 22.44 kcal/day/(0.63 kcal/gX0.47 AE) = 75.79 g/day

Mass of DCSA in soybean forage (broadleaf plant) diet 61.1 mg/kg-ww from max residues from empirical data on dicamba-tolerant soybean forage)

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Mass of DCSA in daily diet mg = 75.79 g/day X 61.1 mg DCSA/kg tortoise prey X 0.001 = 4.63 mg/day

Daily dose in tortoise = 4.63 mg DCSA/day/4.5 kg = 1.03 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck (surrogate for reptiles) for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (34x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

RQ for chronic exposure: RQ = 1.03/40.88 = 0.03.

An RQ of 0.03 does not exceed the chronic LOC of 1.0 for listed species. Consequently, as it relates to DCSA, a "no effect" determination is concluded for the gopher tortoise.

EPA makes a "no effect" determination for the gopher tortoise.

2.3.7.3.3. Indigo snake

The Eastern Indigo Snake is known or believed to occur in Alabama, Florida and Georgia (USFWS Species Profile Page, http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=C026). In Georgia, the species has been observed moving from sandhill habitat to the vicinity of agricultural fields in summer (Speake et al., 1978). Therefore, the species was determined to potentially occupy treated cotton and soybean fields and thus have the potential to be exposed to dicamba on the treated field. The indigo snake feeds largely on other snakes, small tortoises, small mammals, and amphibians (USFWS, 1982). Using the conservative assumptions that the prey species is represented by a 35g mammal that feeds exclusively on contaminated short grass receiving the upper bound Kenaga residues from the spray application of dicamba and that the snake exclusively feeds on this prey species, the assumptions were adjusted to account for the indigo snake's biology:

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $0.0530(4300)^{0.799}$ = 42.4 kcal/day
(USEPA 1993, body weight reflects screening assumption for the indigo snake from Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency,
Office of Pesticide Programs July 15, 2013)

Mass of prey consumed per day = 42.4 kcal/day/(1.7 kcal/g ww X 0.78 AE) = 32 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.78 is assimilation efficiency from USEPA 1993, assumption of small mammal prey from the recovery plan (USFWS, 1983) and Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency, Office of Pesticide Programs July 15, 2013).

Mass of dicamba in a 35-g mammal diet 160 mg/kg-ww from T-REX run

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Mass of dicamba in daily diet = 32 g/day X 160 mg dicamba DGA/kg-ww mammal prey X 0.001 = 5.12 mg/day

Daily dose in snake= 5.12 mg dicamba/day/4.3= 1.25 mg/kg-bw/day

Appropriate scaling factors are not available for reptiles and amphibians so the acute toxicity value for the bobwhite quail (most sensitive avian species for which acute data are available) serves as a surrogate (USEPA, 2004) toxicity value for the tortoise:

Snake LD50 mg/kg-bw = 188 mg/kg-bw

The RQ for acute effects = 1.25/188 = 0.006

An acute RQ of 0.006 does not exceed the acute listed species LOC of 0.1 for listed species. Consequently, as to parent dicamba, EPA makes a "no effect" determination for the indigo snake.

DCSA Assessment for Indigo Snake Consuming Prey that had Previously Consumed Soybean Forage

The indigo snake feeds largely on other snakes, small tortoises, small mammals, and amphibians (USFWS, 1983). Using the conservative assumptions that the prey species is represented by a mammal that feeds exclusively on exposed soybean plant tissue containing the maximum measured DCSA residues of 61.1 ppm and that the snake exclusively feeds on this prey species, the assumptions were adjusted to account for the indigo snake's biology:

Field metabolic rate kcal/day = $0.0530(4300)^{0.799}$ = 42.4 kcal/day
(USEPA 1993, body weight reflects screening assumption for the indigo snake from Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency,
Office of Pesticide Programs July 15, 2013)

Mass of prey consumed per day = 42.4 kcal/day/(1.7 kcal/g ww X 0.78 AE) = 32 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.78 is assimilation efficiency from USEPA 1993, assumption of small mammal prey from the recovery plan (USFWS, 1983) and Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency, Office of Pesticide Programs July 15, 2013).

Mass of DCSA in a mammal diet 61.1 mg/kg-ww (maximum empirical residue data on soybean forage)

Mass of DCSA in snake's daily diet = 32 g/day X 61.1 mg dicamba DGA/kg-ww mammal prey X 0.001 = 1.96 mg DCSA/day

Daily dose in snake= 1.96 mg DCSA/day/4.3= 0.46 mg/kg-bw/day

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck (surrogate species for reptiles) study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.

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RQ for chronic exposure: RQ = 0.46/40.88 = 0.01

An RQ of 0.01 does not exceed the chronic LOC of 1.0 for listed species. Consequently, as to DCSA, a "no effect" determination is concluded for the Eastern indigo snake.

EPA makes a no effect determination for the Eastern indigo snake.

2.3.7.3.4. Houston toad

Historically, Houston toads ranged across the central coastal region of Texas in grassland/prairie ecosystems or in or near forested habitat and metamorphosed adult toads likely eat small terrestrial arthropods (USFWS, 2011b; https://ecos.fws.gov/docs/five_year_review/doc3958.pdf). As a conservative approach, EPA used the modeled upper bound T-REX residues for arthropods. This is considered a conservative approach as 100% of the toad's diet would be considered to consist of exposed arthropods receiving the upper bound Kenaga nomogram dicamba residues from the spray application. A biologically representative assessment follows:

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $0.0530(45)^{0.799}$ = 1.1 kcal/day
(USEPA 1993, body weight reflects screening assumption for the Houston toad from Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency,
Office of Pesticide Programs July 15, 2013)

Mass of prey consumed per day = 1.1 kcal/day/(1.7 kcal/g ww X 0.72 AE)= 0.9 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from USEPA 1993, insect diet assumption from USFWS, 2011b and Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency, Office of Pesticide Programs July 15, 2013)

Mass of dicamba in insect diet 96 mg/kg-ww from T-REX run

Mass of dicamba in daily diet = 0.9 g/day X 96 mg dicamba DGA/kg-ww insect prey X 0.001 = 0.086 mg/day

Daily dose in toad= 0.086 mg dicamba/day/0.045= 1.92 mg/kg-bw/day

Toad LD50 mg/kg-bw = 188 mg/kg-bw
  (assumes the same scaling as for birds)

The RQ for acute effects = 1.92/188 = 0.01

An acute RQ of 0.01 does not exceed the acute listed species LOC of 0.1 for listed species. Consequently, as it relates to parent dicamba, EPA makes a "no effect" determination for the Houston toad.

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EPA considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as 100% of the toad's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. A biologically representative assessment follows:

> Field metabolic rate kcal/day = $0.0530(45)^{0.799}$ = 1.1 kcal/day
> (USEPA 1993, body weight reflects screening assumption for the Houston toad from Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency,
> Office of Pesticide Programs July 15, 2013)
>
> Mass of prey consumed per day = 1.1 kcal/day/(1.7 kcal/g ww X 0.72 AE)= 0.9 g/day
> (1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from USEPA 1993, insect diet assumption from USFWS, 2011b and Biological Information on Listed Species of Amphibians and Model Parameterization for Pesticide Effects Determinations, United States Environmental Protection Agency, Office of Pesticide Programs July 15, 2013)
>
> Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)
>
> Mass of DCSA in daily diet = 0.9 g/day X 42.5 mg dicamba DGA/kg-ww insect prey X 0.001 = 0.038 mg/day
>
> Daily dose in toad= 0.038 mg DCSA/day/0.045= 0.85 mg/kg-bw/day
>
> Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck (surrogate species for terrestrial-phase amphibians) study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of 40.88 mg/kg-diet.
>
> RQ for chronic exposure: RQ = 0.85/40.88 = 0.02

An RQ of 0.02 does not exceed the chronic LOC of 1.0 for listed species. Consequently, as it relates to DCSA, a "no effect" determination is concluded for the Houston toad.

EPA makes a no effect determination for the Houston toad.

2.3.7.4. Listed Mammal Species on Treated-Field

The screening-level risk assessment indicated no acute risk to mammals. **(Section 1)**. The screening-level risk assessment indicated that there was potential for chronic risk from exposures of mammals to

the formation of dicamba's metabolite DCSA in dicamba-tolerant soybean, but that exposures to DCSA in DT-cotton plants were at levels that did not pose a risk concern. Therefore, EPA only conducted a refined assessment for chronic exposures to DCSA in soybeans for listed species that could reasonably be expected to occur on treated soybean fields.

Eleven listed mammal species are reasonably expected to occur on treated soybean fields. Species specific biological information were considered in more depth to further refine the assessment and effects determinations for the eleven species potentially expected to occur on treated soybean fields.

2.3.7.4.1. Gray Wolf

According the USFWS Recovery Plan (USFWS 1992; https://ecos.fws.gov/docs/recovery_plan/920131.pdf), gray wolves are habitat generalists that live throughout the northern hemisphere. Gray wolves are a carnivorous species that typically feed on ungulate species, such as deer. While not likely to feed on agricultural fields themselves, the primary prey species of the gray wolf may be expected to feed on plant material within the field during the period of applications. Based on this information, it is reasonable to conclude that the gray wolf may be exposed to DCSA residues in prey. A biologically representative assessment follows:

DCSA Assessment for Gray Wolf Consuming Prey that had Previously Consumed Soybean Forage

The first step in the assessment is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EPA calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day
1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day
DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = 9.34 mg/kg-bw/day

The next step is to calculate the expected daily dose for a typical 17.7 kg (17700 g) gray wolf, the adjusted NOAEL value and the chronic dose-based RQ for the gray wolf based on the following allometric equations:

Food Intake (wet) = $(0.235(17700)^{0.822})$/(1-0.69)/1000 = 2.35 kg wet/day
Dose-based EEC in wolf eating small mammal= 9.47 mg/kg wet x 2.35/(17700/1000) = 1.24 mg/kg-bw/day

Adjusted NOAEL = 8 mg/kg-bw $(350/17700)^{(0.25)}$ = 3.00 mg/kw-bw
Chronic Dose-Based RQ = 1.25/3.00 = 0.41
An RQ of 0.41 does not exceed the chronic LOC of 1.0 for listed species; consequently a "no effect" determination is concluded for the Gray Wolf.

2.3.7.4.2. Jaguar

DCSA Assessment for Jaguar Consuming Prey that had Previous Consumed Exposed Soybean Forage

Jaguars are ambush hunters with large home ranges, capable of feeding on a wide variety of prey, though medium-sized (1-10 kg) and larger prey appear to be much more commonly used than smaller prey species (USFWS, 2018; https://ecos.fws.gov/docs/recovery_plan/Final%20Jaguar%20Recovery%20Plan_July%202018.pdf, Rosas-Rosas, 2006 and López-González and Miller, 2002). Using the conservative assumptions that the prey species is represented by a 1000 g mammal that feeds exclusively on exposed soybean forage containing the maximum measured DCSA residues (61.1 mg/kg), exposure assumptions were adjusted to account for the jaguar's biology:

> The first step in the assessment is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EPA calculated the residues based on the following allometric equations (USEPA, 1993):
>
> 1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day
>
> 1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day
>
> DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = 9.34 mg/kg-bw/day
>
> The next step is to determine the expected daily dose for a typical 45 kg jaguar, the adjusted NOAEL value and the chronic dose-based RQ for the jaguar based on the following allometric equations:
>
> Field metabolic rate kcal/day = $0.6167(45000)^{0.862}$= 6326 kcal/day
> (USEPA 1993, body weight reflects screening assumption for the jaguar from Recovery Plan, USFWS 2012; http://ecos.fws.gov/docs/recovery_plan/049777%20-%20Jaguar%20Recovery%20Outline%20-%20April%202012_2.pdf)
>
> Mass of prey consumed per day = 6326 kcal/day/(1.7 kcal/g ww X 0.84 AE)= 4430 g/day
> (1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, 1 kg mammal diet from Recovery Plan, USFWS 2012; http://ecos.fws.gov/docs/recovery_plan/049777%20-%20Jaguar%20Recovery%20Outline%20-%20April%202012_2.pdf)
>
> Mass of DCSA in 1 kg mammal diet = 9.34 mg/kg-ww (conservative estimate for a 1 kg mammal feeding on soybean forage containing the maximum measured empirical residues of 61.1 mg/kg)
>
> Mass of DCSA in daily diet = 4430 g/day X 9.34 mg DCSAA/kg-ww mammal prey X 0.001 = 41.38 mg/day
>
> Daily dose in jaguar = 41.38 mg DCSA/day/45 kg = 0.92 mg/kg-bw/day

Jaguar NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/45000)^{(0.25)}$ = 2.38 mg/kg-bw

The RQ for chronic effects = 0.92/2.38 = 0.39

A chronic RQ of 0.39 does not exceed the chronic LOC of 1.0 for listed species. Consequently, a "no effect" determination is made for the jaguar.

2.3.7.4.3. Indiana Bat

The USFWS Recovery Plan (USFWS 2007; https://ecos.fws.gov/docs/recovery_plan/070416.pdf) states that most Indiana bat maternity colonies have been found in agricultural areas with fragmented forests. According to the Recovery Plan there are some 235,000 individual bats within the hibernacula of the states subject to the Federal action. The Recovery Plan also indicates that the sex ratio of males to females is roughly equal. Therefore, there are approximately 117,500 female bats within the hibernacula that are found in the states for this action.

While bats may be associated with forested areas proximal to agricultural land, data on the extent and possibility of foraging over agricultural fields is limited. The Recovery Plan states that observations of light-tagged animals and bats marked with reflective bands indicate that Indiana bats typically forage in closed to semi-open forested habitats and forest edges and that radio-tracking studies of adult males, adult females, and juveniles consistently indicate that foraging occurs preferentially in wooded areas, although type of forest varies with individual studies. The Recovery Plan states that Indiana bats hunt primarily around, not within, the canopy of trees, but they occasionally descend to sub-canopy and shrub layers. The Recovery Plan also states that Indiana bats have been caught, observed, and radio-tracked foraging in open habitats; analyses of habitats used by radio-tracked adult females while foraging versus those habitats available for foraging have been performed in two states.

In Illinois, floodplain forest was the most preferred habitat, followed by ponds, old fields, row crops, upland woods, and pastures. In Indiana, woodlands were used more often than areas of agriculture, low-density residential housing, and open water, and this latter group of habitats was used more than pastures, parkland, and heavily urbanized sites. Old fields and agricultural areas seemed important in both studies, but bats likely were foraging most often along forest-field edges, rather than in the interior of fields, although errors inherent in determining the position of a rapidly moving animal through telemetry made it impossible to verify this. The Recovery Plan remarks that visual observations suggest that foraging over open fields or bodies of water, more than 50 m (150 ft) from a forest edge, does occur, although less commonly than in forested sites or along edges. The Recovery Plan places feeding within agriculturally managed areas of lesser significance than forested areas and their immediate edges.

The Recovery Plan reports that in Illinois, 67 percent of the land near one colony was agricultural, and in Michigan, land cover consisted of 55 percent agricultural land. Recovery Plan discussion of available proportions of different land covers encompassing foraging habitat are limited, but the available literature suggests that foraging in agricultural lands relative to other habitats is variable with study. Sparks et al. (2005), in radio-tracking bats in Indiana, found that the number of telemetry observations of foraging was closely associated with the availability of agricultural land within the home range of the

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species and accounted for approximately 35 percent of observations. In contrast, Murray and Kurta (2004) radio-tracked Indiana bats in Michigan and found that, despite the study area being over 60 percent agricultural land, the habitats frequented by 12 of the 13 monitored bats was forest land. It should be noted that exact frequencies could not be established because triangulation of individual observation points precluded exact locations in different cover types with any confidence. Menzel et al. (2005) radio-tracked bats in Illinois and found that bats foraged significantly closer to forest roads and riparian habitats than agricultural lands. A ranking of the foraging use of habitats suggested the following order of preference by bats in this study: roads> forests> riparian areas> grasslands>agricultural lands (Menzel et al, 2005).

The Recovery Plan indicates that the prey base for the Indiana bat consists primarily of flying insects, with only a very small amount of spiders (presumably ballooning individuals) included in the diet. Four orders of insects contribute most to the diet: Coleoptera, Diptera, Lepidoptera, and Trichoptera. The Recovery Plan concludes that the diet of Indiana bats, to a large degree, may reflect availability of preferred types of insects within the foraging areas that the bats happen to be using, again suggesting that they are selective opportunists.

Given the above information, it is reasonable to conclude that Indiana bats make use of agricultural land as a source of prey and can reasonably be expected to roost in patches of fragmented forest that are adjacent to cotton and soybean fields. They are opportunistic foragers and are expected to forage over many different land covers, including agricultural land, on a broad range of insects/arthropods. A survey of insect populations in agricultural fields reveals a variety of flying, foliage- and ground-dwelling invertebrates comprising a large number of taxonomic groups that could provide on-field prey sources for bats foraging over these areas. However, the extent of foraging over agricultural land is expected to be less than the degree of foraging around the canopies of forested areas.

DCSA Assessment for Indiana Bat Consuming Prey that had Previously Consumed Soybean Forage

This assessment accounts for the bat's biology and includes the conservative assumption that bats would feed exclusively on exposed insects/arthropods that fed on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

Field metabolic rate kcal/day = $0.6167(5.4)^{0.862}$= 2.64 kcal/day (USEPA 1993, body weight reflects screening assumption for the Indiana bat)

Mass of prey consumed per day = 2.64 kcal/day /(1.7 kcal/g ww X 0.87AE)= 1.78 g/day

Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 1.78 g/day X 42.5 mg DCSA/kg-ww insect prey X 0.001 = 0.076 mg/day

Daily dose in bat = 0.076 mg DCSA /day/0.0054 kg = 14.01 mg/kg-bw/day

Indiana Bat NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/5.4)^{(0.25)}$ = 22.70 mg/kg-bw

RQ for chronic exposure: RQ = 8.00/22.70 = 0.62

An RQ of 0.62 does not exceeds the chronic LOC of 1.0 for listed species; consequently a "no effect" determination is concluded for the Indiana Bat.

2.3.7.4.4. Ozark Bat

The Ozark big-eared bat inhabits caves and cliffs that can be found in large blocks of forest to small forest tracts interspersed with open areas. Land use of surrounding areas does not appear to influence location of occupied maternity caves and hibernacula. The Recovery Plan (USFWS, 1995; https://ecos.fws.gov/docs/recovery_plan/950328b.pdf) indicates that the prey base for the Ozark bat consists primarily of lepidopterans and that edge habitat between forested and open areas is the preferred foraging area. Open areas allow for easy foraging because bats are not obstructed by branches while pursuing prey and are able to discriminate insects at greater distances. Based on this information, EPA cannot preclude the possibility that the Ozark bat forages on agricultural fields.

This assessment for the Ozark bat accounts for the bat's biology and included the conservative assumption that bats would feed exclusively on exposed insects/arthropods that fed on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

DCSA Assessment for Ozark Bat Consuming Prey that had Previously Consumed Soybean Forage

This assessment for the Ozark bat accounts for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods feeding on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

Field metabolic rate kcal/day = $0.6167(7.0)^{0.862}$= 3.30kcal/day (USEPA 1993, body weight reflects screening assumption for the Ozark bat)

Mass of prey consumed per day = 3.30 kcal/day /(1.7 kcal/g ww X 0.87AE)= 2.23 g/day

Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 2.23 g/day X 42.5 mg DCSA/kg-ww mammal prey X 0.001 = 0.095 mg/day

Daily dose in bat = 0.095 mg DCSA/day/0.007 = 13.54 mg/kg-bw/day

Ozark Bat NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/7.0)^{(0.25)}$ = 21.27 mg/kg-bw

RQ for chronic exposure to max DCSA residues: RQ = 13.54/21.27 = 0.64

An RQ of 0.64 does not exceed the chronic LOC of 1.0 for listed species; consequently a "no effect" determination is concluded for the Ozark Bat.

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2.3.7.4.5. Florida bonneted bat

The Florida bonneted bat uses a variety of natural and developed areas including Pine flatwoods, pine rocklands, cypress, hardwood hammocks, mangroves, wetlands, rivers, lakes, ponds, canals, other natural areas, rural and agricultural lands including groves, tropical gardens, and crop-based agriculture. The proposed rule for designating the bat's critical habitat (USFWS, 2020; https://www.govinfo.gov/content/pkg/FR-2020-06-10/pdf/2020-10840.pdf#page=1) notes that it feeds on flying insects of the following orders: Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Lepidoptera (moths), and Trichoptera (caddisflies). Based on this information, EPA cannot preclude the possibility that the Florida bonneted bat forages on agricultural fields.

This assessment for the Florida bonneted bat accounts for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods which have fed on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

DCSA Assessment for Florida Bonneted Bat Consuming Prey that had Previously Consumed Soybean Forage

This assessment for the Florida bonneted bat accounts for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods which have fed on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

Field metabolic rate kcal/day = $0.6167(55.0)^{0.862}$= 19.5 kcal/day (USEPA 1993, body weight reflects screening assumption for the Florida bonneted bat, from Harvey, M.J., Altenbach, J.S. and T.L. Best. 2011. Bats of the United States and Canada. JHU Press.)

Mass of prey consumed per day = 19.5 kcal/day /(1.7 kcal/g ww X 0.87AE)= 13.2 g/day

Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 13.2 g/day X 42.5 mg DCSA/kg-ww mammal prey X 0.001 = 0.56 mg/day

Daily dose in bat = 0.56 mg DCSA/day/0.055 = 10.2 mg/kg-bw/day

Florida Bonneted Bat NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/55)^{(0.25)}$ = 12.7 mg/kg-bw

RQ for chronic exposure to DCSA: RQ = 10.2/12.7 = 0.80

An RQ of 0.80 does not exceed the chronic LOC of 1.0 for listed species; consequently a "no effect" determination is concluded for the Florida bonneted bat.

2.3.7.4.6. Virginia big-eared bat

Foraging areas for the Virginia big-eared bat are generally located within a few miles of roost sites and consist of a mix of primarily forested habitats interspersed with open fields/hay fields, cliff lines, rock shelters or outcrops, riparian areas, and water sources such as streams, ponds, and wetlands (USFWS, 2019c; https://ecos.fws.gov/docs/recovery_plan/20190313_Draft%20VBEB%20Recovery%20Plan%20Amendment.pdf). The 2019 recovery plan amendment notes that the Virginia big-eared bat feeds primarily on insects, with more than 80% of the big-eared bat's diet coming from lepidopteran (moths) prey (USFWS, 2019c. This assessment for the Virginia big-eared bat accounts for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods that fed on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

DCSA Assessment for Virginia Big-Eared Bat Consuming Prey that had Previously Consumed Soybean Forage

Field metabolic rate kcal/day = $0.6167(7g)^{0.862}$ = 3.3 kcal/day
(USEPA 1993, body weight 7 g reflects screening assumption for the bat Species Profile Page, accessible at: https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A080)

Mass of prey consumed per day = (3.3 kcal/day)/(1.7 kcal/g ww X 0.87 AE) = 2.2 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.87 is assimilation efficiency from USEPA 1993)

Mass of DCSA in insect diet = 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 2.2 g/day X 42.5 mg DCSA/kg-ww mammal prey X 0.001 = 0.094 mg/day

Daily dose in bat = 0.094 mg DCSA/day/0.007 kg = 13.357 mg/kg-bw/day

Bat NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/7)^{0.25}$ = 21.27 mg/kg-bw

RQ for chronic exposure = RQ =13.357/21.27 = 0.63

A chronic RQ of 0.63 does not exceed the chronic LOC of 1.0 for listed species; consequently a "no effect" determination is concluded for the Virginia big-eared bat.

2.3.7.4.7. Ocelot

This assessment accounts for the recovery plan for the ocelot (USFWS, 2016b; https://ecos.fws.gov/docs/recovery_plan/Ocelot%20Final%20Recovery%20Plan_Signed_July%202016_new%20(1).pdf) describes the ocelot's habitat in Texas as dense thornscrub communities on Laguna Atascosa National Wildlife Refuge and on private lands in three Texas counties. The ocelot requires dense vegetation (>75% canopy cover), with 95% cover of the shrub layer preferred in Texas and it feeds

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primarily on rabbits, rodents, and birds (USFWS, 2016b). Although this indicates the ocelot is unlikely to inhabit agricultural row crop areas, the prey species it feeds on could be exposed in soybean or cotton fields and then subsequently consumed by the ocelot away from the field. Using the assumption that the prey species is represented by a 1000 g mammal (conservative as to rabbits) and using the conservative assumptions that the prey feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba, exposure assumptions were adjusted to account for ocelot's biology:

DCSA Assessment for Ocelot Consuming Prey that had Previously Consumed Exposed Soybean Forage

The first step in the assessment is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EPA calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day

1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day

DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = 9.34 mg/kg-bw/day

The next step is to determine the expected daily dose for a typical 16 kg ocelot, the adjusted NOAEL value and the chronic dose-based RQ for the ocelot based on the following allometric equations:

Field metabolic rate kcal/day = $0.6167(16000)^{0.862}$ = 2594 kcal/day
(USEPA 1993, body weight reflects screening assumption for the ocelot from Recovery Plan (USFWS 1990b; http://ecos.fws.gov/docs/recovery_plan/100826.pdf))

Mass of prey consumed per day = 2594 kcal/day /(1.7 kcal/g ww X 0.84 AE)= 1816 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, mammal diet assumption from Recovery Plan (USFWS 1990b; http://ecos.fws.gov/docs/recovery_plan/100826.pdf))

Mass of DCSA in 1kg mammal diet 9.34 mg/kg-ww (based on allometric equations above and maximum empirical residue data on soybean forage)

Mass of DCSA in daily diet = 1816 g/day X 9.34 mg DCSA/kg-ww mammal prey X 0.001 = 16.96 mg/day

Daily dose in ocelot = 16.96 mg DCSA/day/16= 1.060 mg/kg-bw/day

Ocelot NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/16000)^{(0.25)}$ = 3.08 mg/kg-bw

The RQ for chronic effects = 1.06/3.08 = 0.35

A chronic RQ of 0.35 does not exceed the chronic LOC of 1.0 for listed species. Consequently, EPA makes a "No Effect" determination for the ocelot.

2.3.7.4.8. Gulf Coast Jaguarundi

The recovery plan for the jaguarundi (USFWS, 2013b; https://ecos.fws.gov/docs/recovery_plan/FINAL%20Gulf%20Coast%20Jaguarundi%20Recovery%20Plan.pdf) describes the species as using dense thorny shrublands or woodlands and bunchgrass pastures adjacent to dense brush or woody cover and preying mainly on birds, small mammals, and reptiles. Although this indicates the jaguarundi is unlikely to inhabit agricultural row crop areas, the prey species it feeds on could be exposed in soybean fields and then subsequently consumed by the jaguarundi away from the field. Using the assumptions that the prey species is represented by a 1000 g mammal and using the conservative assumptions that the prey feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba, exposure assumptions were adjusted to account for the jaguarundi's biology:

DCSA Assessment for Jaguarundi Consuming Prey that had Previously Consumed Exposed Soybean Forage

> The first step in the assessment is to calculate DCSA residues in the prey species. Using the conservative assumptions that the prey species is represented by a 1000 g mammal that feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EPA calculated the residues based on the following allometric equations (USEPA, 1993):
>
> 1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day
>
> 1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day
>
> DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = 9.34 mg/kg-bw/day
>
> The next step is to determine the expected daily dose for a typical 90 kg jaguarundi, the adjusted NOAEL value and the chronic dose-based RQ for the ocelot based on the following allometric equations:
>
> Field metabolic rate kcal/day = $0.6167(90000)^{0.862}$= 11498 kcal/day
> (USEPA 1993, body weight reflects screening assumption for the jaguarondi from Recovery Plan, USFWS 2012b)
> (http://www.fws.gov/southwest/es/Documents/R2ES/Gulf_Coast_Jaguarundi_DRAFT_Recovery_Plan_24Dec2012.pdf))
>
> Mass of prey consumed per day = 11498 kcal/day/(1.7 kcal/g ww X 0.84 AE)= 8051 g/day
> (1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, 1 kg mammal diet from Recovery Plan, USFWS 2012b)
> (http://www.fws.gov/southwest/es/Documents/R2ES/Gulf_Coast_Jaguarundi_DRAFT_Recovery_Plan_24Dec2012.pdf))

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Mass of DCSA in 1 kg mammal diet 9.34 mg/kg-ww (based on allometric equations above and maximum empirical DCSA residues on soybean forage)

Mass of DCSA in daily diet = 8051 g/day X 9.34 mg DCSA/kg-ww mammal prey X 0.001 = 75.20 mg/day

Daily dose in jaguarundi = 75.20 mg DCSA/day/90= 0.84 mg/kg-bw/day

Jaguarundi NOAEL mg/kg-bw/day = 4 mg/kg-bw X $(350/90000)^{(0.25)}$ = 2.00 mg/kg-bw

The RQ for chronic effects = 0.84/2.00 = 0.42.

A chronic RQ of 0.42 does not exceed the chronic LOC of 1.0 for listed species. Consequently, EPA makes a "no effect" determination for the jaguarundi.

2.3.7.4.9. Mexican Wolf

According to the USFWS listing document (https://www.gpo.gov/fdsys/pkg/FR-2015-01-16/pdf/2015-00441.pdf, USFWS 2015b), Mexican wolves are a carnivorous species that show a strong preference for elk compared to other ungulates, and other documented sources of prey include deer and occasionally small mammals and birds. Mexican wolves are an average of 70 kg and, like other grey wolves, they are habitat generalists. While the species is not likely to feed on agricultural resources itself, the primary prey species of the wolf may be expected to feed on plant material within the field during the period of applications. Based on this information, it is reasonable to conclude that the Mexican wolf may be exposed to DCSA residues in prey and EPA conducted the following species-specific analysis for the Mexican wolf.

DCSA Chronic Effects Assessment for Mexican Wolf Consuming Prey that had Previously Consumed Exposed Soybean Forage

Using the conservative assumptions that the prey species is represented by a 1000 g mammal that feeds exclusively on exposed soybean forage containing the maximum measured DCSA residues (61.1 mg/kg), exposure assumptions were adjusted to account for the wolf's biology:

The first step in the assessment is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EPA calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day
1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day
DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = 9.34 mg/kg-bw/day

The next step is to determine the expected daily dose for a typical 70 kg wolf, the adjusted NOAEL value and the chronic dose-based RQ for the wolf based on the following allometric equations:

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Field metabolic rate kcal/day = $0.6167(70000)^{0.862}$ = 9258 kcal/day (USEPA 1993, body weight reflects mean wolf weight from:
https://www.gpo.gov/fdsys/pkg/FR-2015-01-16/pdf/2015-00441.pdf)

Mass of prey consumed per day = 9258 kcal/day/(1.7 kcal/g-ww X 0.84 AE) = 6483 g/day [1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, 1 kg mammal diet from Whitaker and Hamilton (1998)]

Mass of DCSA in 1 kg mammal diet = 9.34 mg/kg-ww (conservative estimate for a 1 kg mammal feeding on soybean forage containing the maximum measured empirical residues of 61.1 mg/kg)

Mass of DCSA in daily diet = 6483 g/day X 9.34 mg DCSA/kg-ww mammal prey X 0.001 = 60.6
Daily dose in wolf = 60.6 mg DCSA/day/70 kg = 0.9 mg/kg-bw/day
Wolf DCSA chronic NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/70000)^{(0.25)}$ = 2.1 mg/kg-bw

The RQ for chronic effects = 0.9/2.1 = 0.41

A chronic RQ of 0.41 does not exceed the chronic LOC of 1.0 for listed species. Consequently, a "no effect" determination is made for the wolf.

2.3.7.4.10. Northern long-eared bat

The northern long-eared bat is an insectivorous myotine bat (Whitaker and Hamilton, 1998). With an average weight of 6.5 g, this bat forages principally in forested areas but has been shown to forage over water, open clearings and along roads (https://www.gpo.gov/fdsys/pkg/FR-2015-04-02/pdf/2015-07069.pdf, USFWS 2015a). Consequently, its potential use of open areas without canopy could place the species foraging over agricultural land on insects from treated fields. Therefore, EPA conducted the following species-specific analysis for the northern long-eared bat. Using the conservative assumption that the bat's diet consists entirely of insects having been exposed to maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods (specifically, insects) as a conservative pesticide load in the prey base. This is considered a conservative approach as 100% of the bat's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. A biologically representative assessment follows.

DCSA Chronic Effects Assessment for Northern Long-Eared Bat Consuming Prey that had Previous Consumed Exposed Soybean Forage

Field metabolic rate kcal/day = $0.6167(6.5)^{0.862}$ = 3.1 kcal/day
(USEPA 1993, body weight 6.5 g reflects mean weight for the bat based on
https://www.gpo.gov/fdsys/pkg/FR-2015-04-02/pdf/2015-07069.pdf)

Mass of insect prey consumed per day = (3.1 kcal/day)/(1.7 kcal/g ww X 0.87) = 2.1 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.87 is assimilation efficiency from USEPA 1993)

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Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 2.1 g/day X 42.5 mg DCSA/kg-ww insect prey X 0.001 = 0.089 mg/day

Daily dose in bat = 0.089 mg DCSA/0.0065 = 13.73 mg/kg-bw/day

Northern long-eared bat parent dicamba NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/6.5)^{0.25}$ = 21.67 mg/kg-bw

RQ for chronic exposure = 13.73/21.67 = 0.63

A chronic RQ of 0.63 does not exceed the chronic LOC of 1.0 for listed species. Consequently, a "no effect" determination is made for the northern long-eared bat.

2.3.7.4.11. Sonoran pronghorn

Pronghorn consume forbs such as buckwheat, ragweed, milkvetch and borage species as well as some woody species including ironwood and mesquite and succulent fruit such as chain-fruit cholla (USFWS, 2016c). Though many agricultural crops do not provide adequate forage for the pronghorn, some, such as alfalfa do (USFWS, 2016c; https://ecos.fws.gov/docs/recovery_plan/FINAL%20Sonoran%20Pronghorn%20Recovery%20Plan,%202 nd%20Revision%2011.16.16.pdf). The only overlap for the pronghorn is in cotton fields (no overlap for soybean fields) and the screening level analysis has precluded a risk concern for mammals in cotton. Therefore, while there is an overlap for this species with the action area, the risk assessment (Section 1) precludes a concern for mammals, including the pronghorn on cotton.

Since the screening level assessment identified that risks to mammals are not anticipated for dicamba use on dicamba-tolerant cotton (levels of concern were not exceeded for exposure to either dicamba or its degradate DCSA), **a No Effect (NE) determination is concluded for pronghorn feeding on cotton fields.**

2.3.7.5. On-Field Listed Terrestrial Invertebrate Species

The screening-level risk assessment (**Section 1**) determined that there was potential for chronic risk to terrestrial invertebrates, particularly at their larval-stage, based on submitted honeybee laboratory toxicity tests. No other data addressing dietary exposure for non-honeybee terrestrial arthropods for dicamba's toxicity has been submitted to the Agency for dicamba's toxicity to other arthropods. EPA conducted a species-specific assessment for exposure to dicamba among listed species that could reasonably be expected to occur on treated soybean and cotton fields. Of the terrestrial invertebrates potentially at risk in the 34 states, two are reasonably expected to occur on treated soybean and cotton

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fields. Therefore, species specific biological information were considered in more depth for the effects determinations for those species.

2.3.7.5.1. American burying beetle

In the case of the American Burying beetle, exposure of the organism to dicamba via the diet must consider the adult and larval diet of the species. The USFWS (USFWS, 2019d) summarized the dietary habits of the burying beetle in Federal Register / Vol. 84, No. 86 / Friday, May 3, 2019 (https://www.govinfo.gov/content/pkg/FR-2019-05-03/pdf/2019-09035.pdf#page=1). Adults and larvae depend on dead animals (carrion), for food and moisture. Carrion selection for food can include an array of available carrion species and sizes, as well as feeding through capturing and consuming live insects. For reproduction, American burying beetles need appropriately sized carrion, which are buried by the adults and upon which eggs are deposited and larva develop feeding upon the carrion. American burying beetles have been documented using carcasses for reproduction as small as 48 g. For the purposes of a biologically appropriate effects determination for the burying beetle, an adult diet consisting of live insects and carrion and a larval diet of carrion, found and buried by the adults was assumed. EPA conservatively set the carrion size at 48 g for either bird or mammal. EPA considers the lower weight limit to result in conservative dicamba residues because available TREX allometric feeding rate equations indicate that smaller birds and mammals eat proportionally larger amounts of food per body weight and thus ingest larger amounts of dicamba residues on that food. The time from carrion discovery to larval hatching and commencement of consumption of carrion by the larvae is on the order of 6 to 7 days.

T-REX peak estimates of dicamba insect residues were selected as one option for adult burying beetles. There are no alternative lines of evidence available to account for dicamba absorption or residue depuration in insects available to EPA to enable a more realistic insect prey residue estimate. In contrast, the exposure pathway for adult and larval burying beetles eating bird or mammal carrion leads EPA to conclude that T-REX mammal and bird estimates are too unrealistically conservative for a species -specific effects determination for the burying beetle. This is because the residues are estimated based on a conservative assumption that the bird or mammal consumes an entire day of food in an instantaneous moment, without consideration of feeding time availability, absorption rate of dicamba or elimination rate of dicamba. Additional lines of evidence allow for a more realistic approach that can make use of available data on dicamba absorption, and also make more realistic assumptions of dietary intake by the bird or mammal that is the carrion source for the beetle. EPA constructed an EXCEL-based model (**Appendix K**) that breaks each day of potential carrion species exposure to dicamba into hourly steps. The model assumes that the source material to the carrion species is the highest TREX residue assumption for food for birds or animals but, in each time step, the bird or mammal consumes a portion of the T-REX allometrically determined daily diet (a T-REX allometrically derived daily consumption rate) at a rate of 1/10 the day's ration for each of 10 hours of feeding followed by a period of rest for the animal of 14 hours. Absorption of dicamba is not assumed to be 100%, but instead data from mammal and avian residues studies (MRID 51136001 Absorption Distribution Depletion and Excretion in Rats and MRID 00148127-Hen Metabolism) define an absorption rate of dicamba of 0.9 in each carrion class. Once absorbed a portion of the dicamba is metabolized by the animal and a portion retained as indicated by the most conservative organ-specific half-life of dicamba in rat (4 hours MRID 51136001) and chickens (MRID 00148127).   The residue in a potential carrion source (bird or mammal) is then set at the peak dicamba body concentration form all the hourly estimates the model provides,

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conservatively assuming that the bird or animal dies and becomes a carrion source on the hour of peak dicamba residue.

EPA used the conservative peak food item concentrations of dicamba from **Section 1** to directly provide a dicamba concentration in beetle insect prey (96 mg a.e./kg), and as a dietary input to the feeding and depuration model for mammal and bird carrion (short grass 250 mg a.e./kg, see **Appendix K** for depuration model run). The insect residue was 96 mg a.e./kg and the input for **Appendix K** was set at the **Section 1** dicamba residue estimation in short grass of 250 mg a.e./kg. The dicamba residues used for a species-specific burying beetle risk estimation are as follows:

- insect prey for adult burying beetles = 96 mg a.e./kg (T-REX 1.5.2),
- mammalian carrion for adult beetles and larvae= 69 mg a.e./kg (based on a T-REX short grass input to **Appendix K**), and
- avian carrion for adult beetles and larvae = 113 mg a.e./kg(based on a T-REX short grass in put to **Appendix K**)

One extra step for larval beetle exposure to carrion is made taking into account the fact that, once buried, the carrion will be unfed upon for 6 to 7 days while any deposited burying beetle larvae are en-ovo. A time period of 6 days is assigned to the dormant period for buried carrion, during which it is assumed that the resident dicamba is available to invading soil microflora and can degrade at a rate equivalent to the soil aerobic degradation rate of 18 days (see **Section 2.4.2**). At the end of the 6-day dormant period the concentration in dicamba in the carcass will be 79% of the starting concentration at the animal's death. Therefore, the dicamba residues used to a species-specific burying beetle risk estimation are modified as follows:

- insect prey for adult burying beetles = 96 mg a.e./kg,
- mammalian carrion for adult beetles = 69 mg a.e./kg,
- mammalian carrion for larval beetles = 69 mg a.e./kg * 0.79 = 55 mg a.e./kg,
- avian carrion for adult beetles = 113 mg dicamba /kg, and
- avian carrion for larval beetles = 113 mg a.e./kg * 0.79 = 94 mg a.e./kg.

Reliance on the larval effects endpoints alone is insufficient to characterize risk to the American burying beetle, based on the potential differential exposure between adults and larvae and the differences in sensitivity to dicamba between adult and larval terrestrial invertebrates. The species-specific assessment relies on the endpoints appropriate for each life stage. Moreover, because there is insufficient information relative to life stage size and life stage feeding rate for the burying beetle, the effects endpoints are expressed in terms of the concentration of dicamba in the diet of the test organisms at the relevant effects endpoints. The most sensitive NOAEL for adult insects was from MRID 50784603 at 19 µg ai/bee and is equivalent on a dietary concentration basis to 590 mg ai/kg-diet. The most sensitive NOAEL for larval insects was from MRID 50784602 and was 5.1 µg ai/larva/day or 129.7 mg ai/kg-diet.

Incorporation of the conclusions result in a species-specific assessment conceptual model of risks for both larval and adult phase American burying beetles existing on a treated corn, cotton, or soybean field:

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- Dietary exposure for adults is based on the higher of T-REX estimates for insect, mammal, or bird residues (mg/kg-diet) compared with adult effects endpoints expressed in terms of mg/kg-diet. These risk estimates would be compared to a LOC of 1.0 consistent with the availability of a definitive chronic NOAEL.
- A direct larval exposure pathway to pesticide spray is assumed to be incomplete because of the subterranean location of the brood chamber (Federal Register / Vol. 84, No. 86 / Friday, May 3, 2019; https://www.govinfo.gov/content/pkg/FR-2019-05-03/pdf/2019-09035.pdf#page=1.
- Dietary exposure for larvae would be based on the highest of **Appendix K** estimated mammal or bird residues (mg/kg as carrion diet sourced from these taxa) degraded a conservative 6 days in buried carcasses compared with larval effects endpoints expressed in terms of mg/kg-larval diet in a manner consistent with Section 4 screening methods

Dietary Exposure Risks to Adult American Burying Beetle

Tox endpoint = 590 mg a.e./kg-diet
Diet estimate insect = 96 mg a.e./kg

Diet estimate mammal = 69 mg a.e./kg (highest mammalian estimated dietary residues from small mammal consuming exposed short grass, **Appendix K**)
Diet estimate bird = 113 mg a.e./kg (overall highest estimated dietary residues; from a small bird consuming short grass, **Appendix K**)
RQ = (113 mg a.e./kg-diet)/(590 mg a.e./kg-diet) = 0.19
LOC for comparison = 1.0
Conclusion: 0.19 < 1.0

As the RQ is below the LOC, the Agency determines a No Effect for adult burying beetles.

Dietary Exposure Risks to Larval American Burying Beetle

Tox endpoint = 129.7 mg a.e./kg-diet

Diet estimate mammal = 55 mg a.e./kg (highest mammalian estimated dietary residues from small mammal consuming exposed short grass)
Diet estimate bird = 94 mg a.e./kg (overall highest estimated dietary residues; from a small bird consuming short grass)
RQ = (94 mg a.e./kg-diet)/(129.7 mg a.e./kg-diet) = 0.72
LOC for comparison = 1.0
Conclusion: 0.72 < 1.0

As the RQ is below the LOC, the Agency determines a No Effect for larval burying beetles.

Analysis of available species co-location data place the American burying beetle in states where dicamba use on DT-crops is registered for use on cotton and soybean, and an evaluation of available habitat information indicates the species can reasonably be expected to occur on treated fields. Available toxicity information related to dicamba effects on adult and larval insects provided measurement endpoints for lethality which is a direct measure of an impact on individual survival. Assessment of risk using exposure estimates appropriate to the diet, behavior, and life stages of the beetle, coupled with effects endpoints appropriate to adult and larval life stages all resulted in RQ values below the appropriate LOC for listed species. **Considering the impact of new toxicity information and in the absence of any additional data and without consideration of any additional risk mitigation measures, the Effects Determination of the American burying beetle for the presently labeled use of dicamba products on DT-crops in those states is No Effect.**

2.3.7.5.2. Rusty Patched Bumble Bee

The listing for the rusty patched bumble bee (USFWS 2017; https://www.govinfo.gov/content/pkg/FR-2017-01-11/pdf/2017-00195.pdf#page=1) states the species requires a) areas that support sufficient food (nectar and pollen from diverse and abundant flowers to meet its nutritional needs and b) the species requires a constant and diverse supply of blooming flowers. Additionally, the listing document notes, large monocultures do not support the plant diversity needed to provide food resources throughout the rusty patched bumble bees' long foraging season. According to USDA 2017, soybean and cotton are both considered attractive to bumble bees under certain conditions. However, based on a lack of plant diversity presumably in an agricultural field dominated by either cotton or soybean, it is reasonable to assume soybean and cotton fields would make an unsuitable habitat to sustain the rusty patched bumble bee over its aforementioned long foraging season. Consequently, treated soybean and cotton fields are unlikely either to provide the only resource (based on diversity as a likely nutritional requirement) for pollen and nectar or provide enough of a resource (based on a long foraging season) to sustain a healthy bumble bee population. Based on the conservative screening level risk assessment (**Section 1**) and a comparison of RQs to the LOC, risk to bees is not expected if more than 25% of the bee's diet is from untreated sources. Based on the above information regarding a) the bumble bee's need for diverse food resources that soybean and cotton fields do no provide and b) the low proportion of untreated diet necessary to result in exposures below any thresholds of concern, chronic dietary effects are not reasonably expected for the rusty patch bumble bees from DT-crop dicamba product use. **Because neither acute or chronic effects are reasonably expected for the species, the effects determination for the rusty patched bumble bee is "no effect" (NE).**

2.3.8. Critical Habitat Specific Analysis

In addition to the species-specific effects determinations discussed above in Section 2.3, EPA also conducted the same overlap analysis to the critical habitat map information and identified new critical habitat within the expanded action area for listed terrestrial species as described in Section 2.2 (USFWS, 2017). Critical habitat with less than 1% overlap (after accounting for significant digits) are outside the action area and not considered further, critical habitat greater than 1% overlap are inside the action area and require a modification analysis. The critical habitat modification analysis is based on an assessment of how dicamba products used on DT-crops would affect the Principal Constituent

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Elements/Physical or Biological Features (PCE/PBF's) of the designated habitat, as well as how direct species effects outcomes would impact critical habitat's present and future utility for promoting the conservation of a particular listed species. These PCE/PBF's are established by the U.S. Fish and Wildlife Service or National Marine Fisheries Service (the Services). When the available Services' information on critical habitat location shows overlap with the action area (see **Section 2.2**), the Agency will conclude the action "May Effect" a designated critical habitat if any of the following are met:

1. the endangered species uses the agricultural field and there is a direct toxic effect concern for the species
2. if the Services' description of critical habitat characteristics indicates that the action area contains any of the Services established PCE/PBF's that are impacted by dicamba effects (non-monocot plant effects).

If neither of the above conditions are met, EPA will conclude that there is "No Effect."

The only listed species using cotton or soybean fields and with designated critical habitat PCE/PBF's relatable to agricultural fields is the whooping crane, for which agricultural fields were discussed as providing waste grain as a potential food source for migratory cranes. The only way the dicamba product uses on DT-crops could affect this PCE is by making grain potentially toxic to the birds. As there is unlikely to be any edible waste grain remaining following cotton harvesting, it is unlikely that the dicamba uses on cotton could affect this PCE, however the use on soybean could affect this PCE by making waste soybean grain potentially toxic.

The Health Effects Division summarized available soybean grain residues of dicamba in the Human Health Risk Assessment for the Registration Eligibility Decision for Dicamba and Associated Salts (DP317703). Based on the soybean trials results, maximum residues of dicamba were 0.04 ppm in hay, 0.097 ppm in forage, and 8.13 ppm in seed 6-8 days post treatment (MRIDs 43814101 and 44089307). These measured values were used to set the tolerance value of 10 ppm for soybean seeds. The measured residues are not reasonably expected to be at a level raising a concern for direct effects to the whooping crane because the direct effects assessment for this species (presented above in **Section 2.2.4.1**) did not establish a concern for residues in other dietary items at much higher (~approximately 1 order of magnitude) concentrations than would occur at the maximum measured residues in seed or if residues were present even at the tolerance level of 10.0 ppm. Because this analysis shows no direct effects of dicamba at levels that would be expected in the fields as waste grain, there is no modification of critical habitat. Similarly, measured DCSA residues in waste soybean grain (0.44 ppm) would be well below the estimated DCSA concentrations in arthropods (42.5 ppm) used in the direct effects assessment for this species. **Therefore, whooping crane critical habitat within the 34 states in this refined assessment would not be modified.**

2.4. Summary of Conclusions

Overlap analysis, inclusive of all labeled measures to address spray drift, volatility and runoff determined that 23 listed species are within the action area of this Federal Action. Refined risk-based analysis incorporating best available information on the biology of the species leads to a conclusion of No Effect for 22 of these species. Similar analysis lead to a May Effect conclusion in regard to one species, and consultation with and subsequent concurrence by the USFWS (**Appendix L**) lead to a conclusion of not likely to adversely affect (NLAA) for that species.

Table 2.2. Summary of Effects Determinations for Federally Listed Threatened or Endangered Species within the treated field

Species	Effects determination	Crops Pertinent to Effects Determination
Indiana bat	NE	Cotton, Soybean
Florida bonneted bat	NE	Cotton, Soybean
Northern long-eared bat	NE	Cotton, Soybean
Ozark Bat	NE	Cotton, Soybean
Virginia big-eared bat	NE	Cotton, Soybean
Gray wolf	NE	Cotton, Soybean
Mexican wolf	NE	Cotton, Soybean
Jaguar	NE	Cotton, Soybean
Gulf-Coast jaguarundi	NE	Cotton, Soybean
Ocelot	NE	Cotton, Soybean
Sonoran pronghorn antelope	NE	Cotton, Soybean
Whooping crane	NE	Cotton, Soybean
Attwater's greater prairie-chicken	NE	Cotton, Soybean
Eskimo curlew	NLAA*	NA
Gunnison Sage Grouse	NE	Cotton, Soybean
Mississippi Sandhill crane	NE	Cotton, Soybean
California condor	NE	Cotton, Soybean
Eastern Massasauga rattlesnake	NE	Cotton, Soybean
Indigo snake	NE	Cotton, Soybean
Gopher tortoise	NE	Cotton, Soybean
Houston toad	NE	Cotton, Soybean
American burying beetle	NE	Cotton, Soybean
Rusty patch bumble bee	NE	Cotton, Soybean

*EPA reached a May Affect, but Not Likely to Adversely Affect determination for the curlew and upon informal consultation received a concurrence by the USFWS (Appendix L)

Overlap analysis, inclusive of all labeled measures to address spray drift, volatility and runoff determined that only one CH was withing the action area of this Federal Action. This CH was for the whooping crane. Refined analysis of the PCE/PBFs and utilization of the habitat by whooping cranes resulted in a conclusion of No Effect for this CH.

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4. List of Acronyms

BAPMA	N,N-Bis-(3-aminopropyl) methylamine salt of dicamba
BAT	Base Acres Treated
BCS	Bayer CropScience
BE	Biological Evaluation
BMD	Benchmark Dose
BO	Biological Opinion
CAG	Crop Acres Grown
CDL	Cropland Data Layer
CH	Critical Habitat
CoA	Census of Agriculture
ConUS	Contiguous United States
DAT	Days After Treatment
DCSA	3,6-dichlorosalicylic acid (a major degradate of dicamba)
DGA	Diglycoamine salt of dicamba
DMA	Dimethylamine salt of dicamba
DT	Dicamba-tolerant
DTE	Distance to effect
EAAC	Effects Associated Air Concentration
EC25	Concentration leading to 25% effect
EC50	Concentration leading to 50% effect
ECOFRAM	Ecological Committee on FIFRA Risk Assessment Methods
ECOS	Environmental Conversation Online System
EEC	Estimated Environmental Concentration
EFED	Environmental Fate and Effects Division
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FGDC	Federal Geospatial Data Committee
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GIS	Geographic Information System
HED	Health Effects Division
HUC	Hydrologic Unit Code
IC25	Concentration leading to 25% inhibition
IPA	Isopropylamine salt of dicamba
LAA	Likely to Adversely Affect
lbs a.e./A	Pounds of Acid Equivalent per Acre
LC50	Concentration leading to 50% mortality
LD50	Dose leading to 50% mortality
LOAEC	Lowest Observed Adverse Effect Concentration
LOAEL	Lowest Observed Adverse Effect Level
LOC	Level of Concern
MA	May Affect
MC	Monte Carlo
MOA	Mechanism of Action
NASS	National Agricultural Statistics Service
NE	No Effect

NLAA	Not Likely to Adversely Affect
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NOAEC	No Observed Adverse Effect Concentration
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
NRC	National Research Council
OFM	Off-Field Movement
OTM	Off-Target Movement
PCE/PBF	Principal Constituent Elements / Physical or Biological Features
PCT	Percent Crop Treated
PGR	Plant Growth Regulator
PPHD	Prey, Pollination, Habitat and/or Dispersal
PRN	Prairie Rivers Network
PWC	Pesticide in Water Calculator
RQ	Risk Quotient
SAP	Scientific Advisory Panel
SOP	Standard Operating Procedures
SSD	Species Sensitivity Distribution
SUUM	Summary Use and Usage Memo
TIM	Terrestrial Investigation Model
UDL	Use Data Layer
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
VG	Vaporgrip
VGX	Vaporgrip X
VRA	Volatility Reduction Agent
VSI	Visual Signs of Injury

APPENDICIES

The following appendices discuss the studies reviewed by the Agency in support of the dicamba registration. Throughout the document, EPA references different dicamba products in these studies. To orient the reader, the following products were assessed in these studies:

- Clarity (a DGA salt of dicamba, not approved for use in over the top applications to soybean and cotton)
- XtendiMax with Vaporgrip (a DGA salt of dicamba with a volatility reducing agent, approved for over the top applications to soybeans and cotton)
- Tavium (a DGA salt of dicamba with a volatility reducing agent and s-metolachlor, approved for over the top applications to soybeans and cotton)
- Engenia (a BAPMA salt of dicamba approved for over the top applications to soybeans and cotton)

While not approved for over the top applications, Clarity was used in a number of studies designed to bridge the data so that it could be used between the different forms of dicamba.

Appendix A. Laboratory Fate (Humidome) Studies

A number of laboratory studies were conducted in small soil containing chambers (humidomes) to evaluate the volatility of dicamba. The studies were conducted in accordance with ASTM STP1587. In accordance with this protocol, the soil used was a one to one mixture of field soil and Redi-Earth, designed to reduce the variability of soil composition. Redi-Earth is a mixture of fine sphagnum peat moss, dolomite lime, and vermiculite, that contains a high organic carbon content, and may not necessarily be representative of agricultural soils. As a result, the volatility measured in the studies should only be used for comparison purposes (i.e., volatility estimates from humidome studies should only be compared to other humidome studies, not field studies). Major conclusions from the studies included:

- Volatility tended to increase with increases in temperature
- Volatility tended to increase with decreases in formulation pH
- Volatility was not impacted by changes in relative humidity
- Tank mix components can have an impact on volatility, but the underlying reasons for these impacts are unclear.

1. Registrant Studies

1.1. XtendiMax with Vaporgrip

In a laboratory study (MRID 51017509) conducted in September and October 2019, the relative dicamba volatility of MON 76980 (XtendiMax (DGA salt of dicamba) with VaporGrip pH 5.15) was investigated on uncharacterized soil (50% Redi-Earth and 50% US10 field soil mix) under aerobic soil conditions at three temperatures (30ºC, 35ºC, and 40ºC) with humidity levels of 40%, 50% and 60% for a period of 24 hours. In order to study the effects of pH, the test material was mixed with water or potassium hydroxide to generate the following three test formulations: MON 76980 (XtendiMax with VaporGrip pH 5.17), MON 301785 (XtendiMax with VaporGrip pH 3.97), and MON 301784 (XtendiMax with VaporGrip pH 6.36). Soil samples were treated at a target application rate of ca. 0.558 kg a.i./ha (ca. 0.5 lb a.i./A), which is the typical use rate. In general, study authors and the EPA concluded that volatility tended to increase as the temperature in the closed dome increased and that volatility tended to increase as pH of the formulation decreased.

In a laboratory study (MRID 51017511) completed in January 2020, the relative dicamba volatility of 572 unique tank mixtures of XtendiMax with VaporGrip and other agricultural products was studied in soil under aerobic conditions at set temperature (35°C), humidity (40%), and air flow conditions (ca. 3 L/min.) for 24 hours (14 hours of light, 10 hours of darkness). Soil was a 1-liter mixture of a 50 % Redi-Earth and 50 % US10 field soil. Application rates were not reported. Polyurethane foam (PUF) samples were collected after 24 hours. The PUF samples were extracted using methanol, and dicamba was quantified using LC-MS/MS. Based on an analysis of pH versus the dicamba air concentrations for all tank mixes and for each tank mix partner class, pH did not correlate well with 24-hour dicamba air concentrations, such that the measured dicamba air concentrations varied across pH ranges. However, it should be noted that tank mixes with pH lower than that of XtendiMax with Vaporgrip alone were more likely to generate 24-hour dicamba air concentrations higher than those for XtendiMax with Vaporgrip alone. Based on results of a humidome study that assessed temperature and relative humidity effects on the volatility of XtendiMax with Vaporgrip (MRID 51017509), the pH of XtendiMax with Vaporgrip is

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typically around 5.2 and the average 24-hour dicamba air concentration at 35°C and 40% relative humidity was 6.42 ng/m^3. Three hundred and ninety-six partner tank mixes had in air concentrations higher than those attributed to XtendiMax with Vaporgrip alone (6.42 ng/m^3), while 176 combinations resulted in air concentrations less than the XtendiMax with Vaporgrip. Nineteen percent of the tank mixes with air concentrations greater than 6.42 ng/m^3 had pH values less than 5.2 and 81% had pH values greater than or equal to 5.2. In contrast, only 3% of the tank mixtures had air concentrations less than or equal to 6.42 ng/m^3 and pH values less than 5.2 and 97% had pH values greater than or equal to 5.2.

1.2. Engenia

In a laboratory study (MRID 51049001) conducted between July and November of 2019, the relative dicamba volatility of Engenia (BAMPA salt of dicamba) was investigated on partially characterized soil (50% sandy loam soil and 50% Redi-Earth & Seedling Potting Mix) under aerobic soil conditions for a period of approximately 24 hours with varied solution pHs (2 to 7 with an interval of 0.5) under ambient environmental conditions, varied temperatures with ambient relative humidity (ca. 35-50%), and varied relative humidity at ca. 30°C and ca. 40°C. Engenia tank mixtures with other products ("partners") were prepared using Cornerstone Plus, Roundup PowerMAX, Raptor, Reflex, and Outlook and the relative dicamba volatility of the tank mixtures were investigated with the test soil for a period of approximately 24 hours with varied solution pHs under ambient environmental conditions. Soil samples were treated at a target application rate of ca. 0.56 kg a.e./ha (0.5 lb a.e. dicamba/A). Four replicates for each test condition were examined in the study. Mixed Cellulose Ester (MCE) filter samples were collected for 24 hours after application at a target flow rate of 2.00 ± 0.10 L/minute. Study authors and the EPA reviewer concluded that the volatilization of dicamba increased with lowered pH in Engenia alone trials and Engenia tank mix spray solutions trials. The pH range of 6.0-7.0 generally corresponded to reduced volatilization. Increased variability of the replicate data occurred with lowered pH/increased dicamba volatility. Additionally, there was a trend of increased volatilization with higher temperatures (>40°C) and higher relative humidity with higher temperatures.

1.3. Tavium

In a laboratory study (MRID 50958207) conducted from September 2019 to January 2020, the relative dicamba volatility of four tank mixtures of Tavium (DGA salt of dicamba plus S-metolachlor) with Intact was investigated on partially characterized soil [(50% Field soil and 50% Berger BM2 Germinating Mix provided by Hummert International (Item # 79VV9600)] under aerobic soil conditions at 35°C with 40% relative humidity for a period of 24 hours. Tavium with Intact was partnered with one of three herbicide formulations (Roundup PowerMAX (RUPM), Flexstar, and Fusilade DX). In order to study the effects of pH, the four tank mixtures were prepared at target water pHs of 4, 7, and 8 (final water pHs of 4.28, 7.09, and 8.26). Soil samples were treated at a target application rate of ca. 0.56 kg a.e./ha (0.5 lb a.e. dicamba/A), which is the typical use rate on dicamba tolerant soybean and cotton on the Tavium label. Three replicates for each pH were examined in the study. Air was pulled through Polyurethane foam (PUF) filters at a flow rate of ca. 1.85 L/minute and samples were collected for 24 hours. The PUF samples were extracted using methanol, and dicamba was quantified using LC-MS/MS. There was a statistically significant difference (95% confidence level, $p \leq 0.05$) between the dicamba mass detected at the lowest initial carrier pH (pH 4) and volatilized mass measured when the target water solution was 7 or 8. Study authors and the EPA reviewer concluded that the volatilized dicamba mass was greater for pH 4 than pH 7 or 8, with no observed significant difference between 7 and 8 pH levels.

In a laboratory study (MRID 50958208) conducted between October 2019 and January 2020, the relative dicamba volatility of four tank mixtures of Tavium with Intact was investigated on partially characterized soil [(50% Field soil and 50% Berger BM2 Germinating Mix provided by Hummert International (Item # 79VV9600)] under aerobic soil conditions for a period of 24 hours with a nine condition array of temperatures (15ºC, 25ºC, and 35ºC) and relative humidities (20%, 40%, and 60%). Tavium with Intact was separately partnered with each of three other herbicides (Roundup PowerMAX (RUPM), Flexstar, and Fusilade DX). Soil samples were treated at a target application rate of ca. 0.56 kg a.e./ha (0.5 lb a.e. dicamba/A). Three replicates for each test condition were examined in the study. Polyurethane foam (PUF) samples were collected after 24 hours and a target flow rate of ca. 1.85 L/minute (range 1.70-1.87 L/minute). The PUF samples were extracted using methanol, and dicamba was quantified using LC-MS/MS. There was no statistically significant difference between volatilization flux rate of dicamba at any of the relative humidity levels tested. Volatilization rates across tank mixtures were consistent at each temperature level, except for Tank Mix 2 (Tavium, RoundUp Power MAX, and Intact) in which flux was higher than the benchmark tank mixture (Tank Mix 1 – Tavium and Intact) at all temperature levels. Study authors and the EPA reviewer concluded that the measured flux values were statistically different when considering the temperature effects on volatility. The flux measurements at 35°C were significantly higher than comparable measurements at 25°C and 15°C, but there was no observed significant difference between dicamba flux calculated between 15°C and 25°C.

2. Academic Studies

In 2017, Mueller and Steckel[19] investigated the volatility of dicamba following an application to soil in humidomes. Plastic trays (28 x 54 x 6 cm in depth) were individually covered by an 18-cm-tall vented humidity dome that was specifically sized to be attached directly to these trays. To facilitate sample collection, a 10-cm-diam hole was cut using a hole saw into the vented dome, and two small holes (2 cm diam) were also cut to allow for air entrance on the opposite side of the vented dome. A Sequatchie loam soil that had no previous herbicide use was utilized (34% sand, 48% silt, 18% clay, 1.3% organic matter, pH 6.2, and cation exchange capacity 11 mEq/g). Air sampling was conducted using an air sampler main unit equipped with digital readouts for both cumulative air flow and time interval sampling, a microfiber filter paper holder, and a PolyUrethane Filter (PUF) sampling module. The sampling media used was a 10-cm-diam HEPA-type high purity binderless 99.99% efficiency borosilicate glass fiber filter paper and an 8-cm-long polyurethane vapor collection substrate. Three diglycolamine (DGA) herbicide treatments were evaluated: the DGA formulation of dicamba plus glyphosate and the DGA formulation including pH modifier (VaporGrip®) with or without glyphosate. The commercial formulation of Roundup PowerMAX (a potassium salt of glyphosate) (Monsanto, St Louis, MO) was used. Herbicide applications were made to screened, air-dried soil at 0.5 kg ae/ha of dicamba. The dosage of glyphosate was 1.0 kg ae/ha. No additional surfactants or adjuvants were added. Herbicide applications were made at approximately 7:00 am on the day of application. Applications were made outside of the greenhouse and trays were left undisturbed for 10 min after herbicide application, after which they were placed on plastic greenhouse carts with minimum soil disturbance and moved into the greenhouse. Sampling intervals for all experiments were 12 h. There were eight runs of the test with two replications per run of each treatment in a randomized complete block design. Data generated from this research indicate that temperature appears to be a major contributor of dicamba volatility, with

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[19] Mueller, T. and Steckel, L. 2019. Dicamba volatility in humidomes as affected by temperature and herbicide treatment. Weed Technol 33: 541–546. doi: 10.1017/wet.2019.36

greater dicamba detections at higher temperatures (**Figure A.1**). The addition of glyphosate (DGA+Gly and DGA+GLY+VG) and the resulting decrease in spray mixture pH increased dicamba volatilization (concentrations in air) compared with the DGA plus Vaporgrip formulated product alone (DGA+VG). The DGA plus Vaporgrip showed lower dicamba compared with the DGA plus glyphosate treatment, although detectable dicamba residues were noted in every sample. Study authors concluded that the most probable reason for the increased detection of dicamba at higher temperatures and with mixtures of glyphosate is via volatility. EPA reviewers agree with this conclusion.
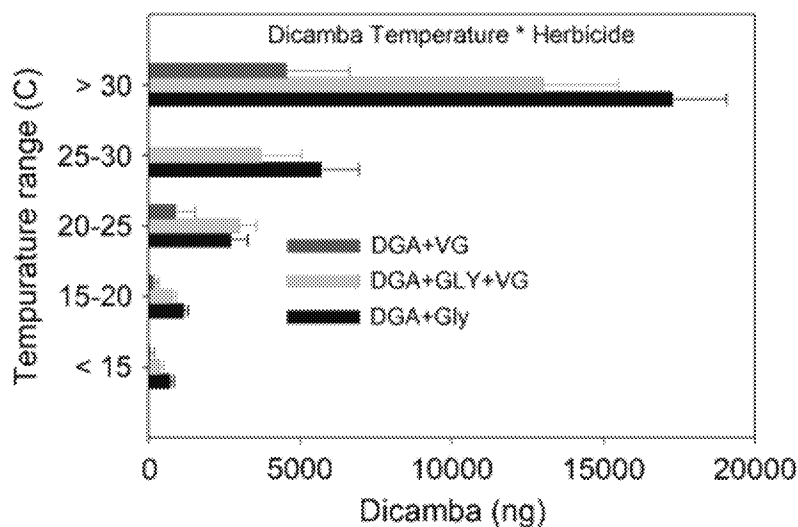
Figure A.1. Evaluation of dicamba volatility in a humidome

Appendix B. Animal and Aquatic Plant Toxicity Data

This appendix provides a full list of the studies and additional study details on the studies EPA evaluated when selecting the most sensitive endpoints for the FIFRA (**Section 1**) and ESA (**Section 2**) portions of the risk assessment. See **Section 1.5** for list of selected endpoints.

Table B.1. Available aquatic animal and plant toxicity studies for dicamba acid, DGA and BAPMA salts.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in μg a.e./L (unless otherwise specified)[1]	MRID or ECOTOX No./ Classification2	Comments[4]
Freshwater Fish (Surrogates for Vertebrates)					
Acute	TGAI Dicamba Acid 88%	Rainbow Trout (Oncorhynchus mykiss)	96-h LC_{50} = 28,000	40098001 Supplemental	Study suitable for quantitative use. Slightly toxic
Acute	TEP DGA 40.2%	Bluegill (Lepomis macrochirus)	96-h LC_{50} > 270,800	00162067 Acceptable	Practically non-toxic
Acute	TEP DGA 40.2%	Rainbow Trout (Oncorhynchus mykiss)	96-h LC_{50} > 270,800	00162068 Acceptable	Practically non-toxic
Acute	TGAI BAPMA 48.4%	Fathead minnow (Pimephales promelas)	96-h LC_{50} > 56,400	48718008 Acceptable	Practically non-toxic
Chronic	TGAI Dicamba Acid 92.9%	Fathead minnow (Pimephales promelas)	22-weeks NOAEC = 9,900 LOAEC >9,900	48718010 Acceptable	
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	TGAI Dicamba Acid 86.8%	Sheepshead minnow (Cyprinodon variegates)	96-h LC_{50} >180,000	00025390 Acceptable	
Chronic	TGAI Dicamba Acid 86.8%	Sheepshead minnow (Cyprinodon variegates)	NOAEC = 11,000 LOAEC > 11,000	48718011 Acceptable	
Freshwater Invertebrates (Water-Column Exposure)					
Acute	TGAI Dicamba Acid 88%	Water Flea (Daphnia magna)	48-h LC_{50} >100,000	40094602 Supplemental	Study suitable for quantitative use. Practically non-toxic
Acute	TEP DGA 40.2%	Water Flea (Daphnia magna)	48-h LC_{50} > 270,800	00162069 Supplemental	Study suitable for quantitative use. Practically non-toxic

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg a.e./L (unless otherwise specified)[1]	MRID or ECOTOX No./ Classification2	Comments[4]
Chronic	TGAI BAPMA 48.4%	Water Flea (Daphnia magna)	NOAEC = 42,000 LOAEC > 42,000	48718007 Acceptable	No observed effects
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute	TGAI Dicamba Acid 86.8%	Grass shrimp (Palaemonetes pugio)	96-h EC_{50} > 100,000	00034702 Acceptable	Practically non-toxic
Chronic	TGAI Dicamba Acid 93.9% ai	Mysid (Americamysis bahia)	NOAEC = 11,000 LOAEC > 11,000	48718012 Acceptable	No observed effects
Aquatic Plants and Algae					
Vascular	TGAI Dicamba Acid 89.5%	Duckweed (Lemna gibba)	IC_{50} >3,250 NOAEC = 200	42774111 Acceptable	Number of fronds reduced 11% at LOAEC of 390 µg ae/L.
Non-vascular	TGAI Dicamba acid 89.5% a.i.	Marine Diatom (Skeletonema costatum)	9-d EC_{50} = 493 NOAEC = 11	42774110 Acceptable	Cell density reduced 25% at LOAEC of 33 µg ae/L.
Non-vascular	TGAI Dicamba Acid 89.5%	Blue-green algae (Anabaena flos-aquae)	9-d EC_{50} = 61 NOAEC = 5	42774109 Acceptable	Cell density reduced 19% at LOAEC of 7.7 µg ae/L.
Non-vascular	TEP Dicamba BAPMA 48.4% a.i.	Green algae (Pseudokirchneriella subcapitata)	72-hr EC_{50} = 7,010 NOAEC = < 170 IC_{05} = 390	48718009 Acceptable	Effect based on yield (reduced cell density)

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient
> Greater than values designate non-definitive endpoints where no effects were observed at the highest level tested, or effects did not reach 50% at the highest concentration tested (USEPA, 2011b).
< Less than values designate non-definitive endpoints where growth, reproductive, and/or mortality effects are observed at the lowest tested concentration.
[1] NOAEC and LOAEC are reported in the same units.
[2] Study classifications of Acceptable and Supplemental indicate that the study is useful for consideration in risk assessments. Studies identified as Supplemental indicate that there was some deviation from the guideline recommendations. Supplemental studies identified as for qualitative use, are not used for generating RQs in risk assessment.
[3]https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/technical-overview-ecological-risk-assessment-0#Ecotox

Table B.2. Available terrestrial toxicity studies for dicamba acid, DGA and BAPMA salts

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1]	MRID or ECOTOX No./ Classification[3]	Comments[4]
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	TGAI Dicamba Acid 86.0%	Bobwhite quail (Colinus virginianus)	LD_{50} = 188 mg a.e./kg-bw	42918001 42774105 Acceptable	Moderately toxic
Acute Oral	TGAI Dicamba Acid 86.0%	Zebra finch (Taeniopygia guttata)	LD_{50} = 207 mg a.e./kg-bw	48718013 Acceptable	Moderately toxic
Acute Oral	TGAI BAPMA 48.4%	Bobwhite quail (Colinus virginianus)	LD_{50} = 1,798 mg a.e./kg-bw	48718006 Acceptable	Practically non-toxic
Sub-acute dietary	TGAI Dicamba Acid 86.0%	Bobwhite quail (Colinus virginianus)	LC_{50} >10,000 mg a.e./kg-diet	00025391 Acceptable	Practically non-toxic
Sub-acute dietary	TEP DGA 40%	Bobwhite quail (Colinus virginianus)	LC_{50} > 609 mg a.e./kg-diet	00162071 Acceptable	Slightly toxic
Sub-acute dietary	TEP DGA 40%	Mallard duck (Anas platyrhynchos)	LC_{50} > 609 mg a.e./kg-diet	00162072 Acceptable	Slightly toxic
Chronic	TGAI Dicamba Acid 86.0%	Mallard duck (Anas platyrhynchos)	NOAEC = 695 LOAEC = 1,390 mg/kg-diet	43814003 Acceptable	based on moderate (11-21%) reductions in the number of hatchlings, 14-day old chicks and 14-day old chicks as a percentage of eggs laid in the 1390 mg a.i./kg-diet treatment group compared to the control group.
Mammals					
Acute Oral	TGAI Dicamba Acid 99.7%.	Laboratory rat (Rattus norvegicus)	LD_{50} = 2,740 mg a.i./kg-bw (males)	00078444	Practically non-toxic
Acute Oral	TGAI Metabolite DCSA 99.7%.	Laboratory rat (Rattus norvegicus)	LD_{50} = 2,641 mg a.i./kg-bw (males)	47899504	Practically non-toxic
Acute Inhalation	TEP Dicamba Acid	Laboratory rat (Rattus norvegicus)	4-hours LC_{50} > 5.3mg a.i./L	00263861 Acceptable	No mortalities at limit dose

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ED_005172C_00001997-00130

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1]	MRID or ECOTOX No./ Classification[3]	Comments[4]
Sub-Chronic Feeding (13 week)	TGAI Dicamba Acid 96.8%	Laboratory rat (Rattus norvegicus)	NOAEL = 500 LOAEL = 1000 mg a.i./kg-bw/day	00128093 Acceptable	Endpoints: reduced body weight
Chronic (2-generation reproduction)	TGAI Dicamba Acid 96.8%	Laboratory rat (Rattus norvegicus)	NOAEL = 136 LOAEL = 450 mg a.i./kg-bw/day	43137101 Acceptable	Endpoints: decreased pup weight in F1 and F2, delayed F0 maturation
Chronic (2-generation reproduction)	TGAI Metabolie DCSA 97.7%	Laboratory rat (Rattus norvegicus)	NOAEL = 8 LOAEL = 78 mg a.i./kg-bw/day	47899517 Acceptable	reduced in offspring weight on 14 and 21 post-natal days (PND)
Terrestrial Invertebrates					
Acute contact (adult)	TEP Dicamba Acid % a.i. unknown	Honey bee (Apis mellifera L.)	LD$_{50}$ > 91 μg a.i./bee	00036935 Supplemental	Study suitable for quantitative use Practically non-toxic
Chronic oral (adult)	TGAI Dicamba acid 98% a.i.	Honey bee (Apis mellifera L.)	NOAEL = 19 LOAEL = 33 μg a.i./bee	50784603 Acceptable	reduced food consumption (24%, relative to controls) at 33 μg a.e./bee; dose response. Solvent used also caused a reduction in food consumption. No treatment-related mortality
Chronic oral (adult)	TGAI Dicamba acid 98% a.i.	Honey bee (Apis mellifera L.)	NOAEL < 64.8 LOAEL = 64.8	50931304 Supplemental (qualitative)	food consumption reduced 44% at the single treatment dose (no solvent used). No treatment-related mortality.
Chronic oral (larval)	TGAI Dicamba acid 93.9%	Honey bee (Apis mellifera L.)	NOAEC = 5,1 LOAEC = 10 μg a.i./larvae	50784602 Acceptable	impacts to pupal mortality (29% inhibition, relative to controls at D15) and reduced adult emergence (28% inhibition at test termination on D22)
Terrestrial and Wetland Plants[2]					

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient

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> Greater than values designate non-definitive endpoints where no effects were observed at the highest level tested, or effects did not reach 50% at the highest concentration tested

< Less than values designate non-definitive endpoints where growth, reproductive, and/or mortality effects are observed at the lowest tested concentration.

[1] NOAEC and LOAEC are reported in the same units.

[2] Discussion of studies for terrestrial and wetland plants is provided in Appendices C and E

[3] Study classifications of Acceptable and Supplemental indicate that the study is useful for consideration in risk assessments. Studies identified as Supplemental indicate that there was some deviation from the guideline recommendations. Supplemental studies identified as for qualitative use, are not used for generating RQs in risk assessment.

[4]https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/technical-overview-ecological-risk-assessment-0#Ecotox

Appendix C. Greenhouse and Field Based Terrestrial Plant Dose Response Toxicity Data

1. Evaluation of Available Endpoints in Dicamba Toxicity Studies For use in FIFRA and ESA Assessments

To assess the effects on organisms exposed to a chemical stressor, EPA evaluates the available ecotoxicological literature to determine effects directly relating to an organism's fitness in the environment (*i.e.* effects reducing an organisms' survival, reproductive capacity and/or physiological growth; USEPA, 2004). These effects are direct inhibitions of an organism's ability to survive, reproduce, or grow. Terrestrial plant reproduction (e.g., yield) is not easily measured under greenhouse conditions, therefore EPA typically relies upon plant measurement endpoints of plant height and weight, which are commonly observed in greenhouse studies. Plant height and weight have meaning in the context of survival and reproductive potential of species in the environment. Plant growth endpoints address the ability of plants to compete for resources, thereby enhancing survival, and achieving sufficient growth to obtain adequate resources for the increased energetic needs of reproduction.

As mentioned above, EPA typically uses measurements plant height from greenhouse studies conducted under conservative conditions that ensure exposure at measured doses as opposed to field studies that test phytotoxic effects under more variable environmental conditions. From these studies, EPA relies upon the most sensitive species' Effective Concentration (EC_{25}) or Inhibition Concentration (IC_{25}) that resulted in a 25% reduction for estimating risks to non-listed terrestrial plant species. The associated NOAEC (No Observed Adverse Effect Concentration) from the same test is used as the effect threshold to determine whether exposures are above the threshold level for ESA Effects Determinations. EPA also commonly calculates a regression estimate of the 5% effect level (EC_{05} or IC_{05}) that is used in lieu of the NOAEC when a NOAEC cannot be determined from the study.

Many of the available field studies evaluating plant response to dicamba exposure report the measurement of visual signs of injury (VSI) as the only endpoint for the study. While measurement endpoints of height and weight are routinely used to calculate the risk quotients that support ESA Effects Determinations, generally EPA has taken the position that they do not represent a limitation on the types of toxicity endpoints that may be considered (USEPA 2004, https://www.epa.gov/sites/production/files/2014-11/documents/ecorisk-overview.pdf). The assessor may encounter other effects data, such as the measurement of VSI, that provide insight on endpoints not routinely considered for calculation. Professional judgment is used and documented by the assessor to determine whether and how available data on endpoints such as VSI are included in the risk assessment. EPA investigated multiple lines of evidence to inform whether the use of VSI in this risk assessment would be appropriate (additional considerations are discussed in Appendix D.1). The lines of evidence used to determine the appropriate endpoint selection for determining dicamba risk included:

- consideration of the dicamba herbicidal mechanism of action (MOA) and whether VSI and height or yield effects are grounded in a common biologically relevant mechanism (**Section C.1.1**);
- the biological implications of dicamba exposure at specific growth stages of tested plants and the whether there are relationships between the measurement of VSI and other measurement endpoints (e.g., height; **Sections C.2, C.3 and C.5**); and

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- an evaluation of VSI observations relative to observations of height and yield effects in dose response studies to explore whether there are quantitative relationships between VSI and height or yield effects (**Appendix D**).

1.1. Considering the Dicamba Herbicidal Mechanism of Action

EPA evaluated whether there is a plausible mechanistic link between VSI responses as an indicator of impacts on growth or reproduction for purposes of this risk assessment. Dicamba is an auxin (indole-3-acetic acid) mimicking compound (Kelley and Riechers 2007). Auxin governs dynamic cellular processes involved at several stages of plant growth and development. Although the precise mechanism of action of auxin herbicides is not fully understood, the mechanism appears to involve a stimulation of ethylene production leading to an accumulation of abscisic acid and/or cyanide resulting in abnormal growth. At sufficiently high levels of exposure, the abnormal growth is so severe that vital functions cannot be maintained and the plant dies. The differential toxicity of dicamba to various plant species is based on variations in the ability of different plants to absorb, translocate, and degrade the herbicide. The mode of action, the induction of hormonal imbalance, is specific to plants and does not affect animals (USDA, 2004; available at: https://www.fs.fed.us/foresthealth/pesticide/pdfs/112404_dicamba.pdf.)

The most typical symptom of dicamba is epinasty, or curved and twisted stems and leaves. This is one of the primary symptoms observed and used when scoring VSI. Derr et al. (no publication data, http://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/PPWS/PPWS-77/PPWS-77P-pdf.pdf) suggests this abnormal growth is caused by the auxin-mimicking effect of the herbicide stimulating growth on different sides of an organ. In addition, VSI is also manifested in the form of meristematic inhibition. This is also a symptom used for VSI scoring, where leaf edge meristems are inhibited by dicamba, and often force the leaf to form a cup-shape. This cupping is often associated with a darker green color and a bunched, or puckered, appearance (Iowa State University, no date, http://agron-www.agron.iastate.edu/~weeds/Ag317/manage/herbicide/dicamba.html and Cornell University, no, date https://weedecology.css.cornell.edu/herbicide/herbicide.php?id=2).

In summation, the mechanism that causes epinasty and meristematic inhibition, rapid abnormal growth through the auxin-like characteristics of dicamba, is the same mechanism that ultimately disrupts the nutrient flow of the plant leading to reduced growth and reproduction.

1.2. Conservatism of Endpoints for Consideration in the FIFRA and ESA Assessment

EPA selected a suite of effects endpoints for the non-target plant risk assessment under FIFRA and the federally-listed threatened and endangered species effects determinations under ESA. These effects endpoints for evaluation included a 5% reduction in plant growth (plant height measurements) and a 5% reduction in reproduction output (plant yield measurements). Both of these measures are consistent with EPA policy for setting effect thresholds for ESA effects determinations. In terms of evaluating non-listed species under FIFRA, the typical effect levels of concern are established at a higher 25% effect level. So, the reliance on 5% thresholds for non-listed plants in this assessment is considered very conservative.

In addition to these growth and reproduction effects thresholds, EPA also considered the measurement of VSI as an endpoint. EPA established the relationship of the measurements of %VSI and 5% plant height and 5% yield responses to dicamba (**Appendix D**). In the analyses, EPA used studies conducted

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under both greenhouse and field conditions in studies submitted to EPA by registrants and academics. The levels of VSI that correspond to a 5% reduction in height or a 5% reduction in yield are variable across the available data and likely dependent upon soybean variety and a variety of field and agronomic factors. After review of the large body of studies that included VSI observations, and height and yield information, EPA determined that the measurement of 10% VSI is protective of 5% reductions in plant height and yield with a high degree of certainty. The use of 10% VSI is a conservative protective threshold because, based on the available toxicity data, 95% of observed cases of VSI at exposures causing a 5% height or yield reduction were greater than 10% (VSI). Because the measurement of 10% VSI was selected to reasonably avoid occurrence of reaching exposures where off-field 5% reductions of growth or yield would occur, and because other factors are likely important to the ultimate plant growth and yield relationship to any observations of VSI, 10% VSI-alone is not predictive of significant yield loss or growth impairment in non-target plants.

2. Greenhouse Toxicity Studies

2.1. Registrant Submitted Studies

Several relevant seedling emergence (850.4100) and vegetative vigor (850.4150) guideline toxicity studies were submitted to EPA by registrants (**Table C.1**). These include studies that applied Clarity (DGA salt of dicamba), BAPMA salts of dicamba, DGA dicamba + Glyphosate, and Tavium (DGA dicamba + Metolachlor). As described in this Appendix and supported by previous bridging of BAPMA and DGA salts (USEPA 2016a[20]), the data indicate that there is potential differential toxicity within a tested species to these various formulations such that the dicamba DGA salt is not always the most toxic to a given species. The data show that dicots are at least an order of magnitude more sensitive than monocots exposed to either salt formulation. The most sensitive species from all available studies was soybean (MRID 47815102) based on a comparison of the IC_{25} (0.000513 lbs a.e./A) growth endpoints. This IC_{25} and the corresponding regulatory NOAEC of 0.000261 lbs a.e./A, is considered protective of all other species and forms of dicamba considered in this assessment.

2.2. Consideration of the plant response at the Regulatory Endpoint (NOAEC)

The soybean regulatory NOAEC (0.000261 lbs a.e./A; MRID 47815102) was selected at the lowest tested concentration in the study based on EPA arguments provided in USEPA 2013c[21]. As discussed in that memorandum, there was a 9% reduction in plant height at the 0.000261 lbs a.e./A concentration as compared to the controls, but this was not statistically different from the controls in that study. The NOAEC endpoint is used by EPA for comparison to measured spray drift deposition in field based studies (Appendix E). However, as discussed in the risk assessment (Section 1) and Appendix E, this endpoint does not necessarily predict height reductions at a concentration of 0.000261 lbs a.e./A. and is not used for the distance to effect estimates discussed in Appendix E and Appendix F.

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[20] USEPA. 2016a. Memorandum: Dicamba BAPMA salt – Bridging Memorandum for Dicamba BAPMA Salt (Engenia) to Dicamba Acid and Dicamba DGA Salt. Signed December 20, 2016.
[21] USEPA 2013c. Memorandum: Addendum to the Data Evaluation Report on the Toxicity of Clarity 4.0 SL (AI: Dicamba) to Terrestrial Vascular Plants: Vegetative Vigor (MRID 47815102).

Consideration of VSI as it relates to 5% reduction in height

EPA used the results of the studies listed in **Table C.1**. to derive a relationship between soybean measurements of VSI and 5% height (see details in **Appendix D**). Based on the study reports, EPA derived regressions for %VSI and calculated the estimated %VSI at the 5% threshold (**Table C.1**).

Table C.1. Summary of soybean %VSI to 5% height relationships.

	Concentration at 5% height (lbs a.e./A)	% VSI at concentration of 5% height	Ratio of %VSI to 5% Height
DGA -MRID 47815102[1]	0.00011	10.7	2.1
BAPMA Salt – MRID 48718015	0.00017	12.3	2.5
DGA + s-metolachlor – MRID 50102116	0.00252	31.8	6.4
DGA + Glyphosate – MRID 49953901	0.000333	18.6	3.7

[1] 5% height reduction was estimated with ICP regression techniques.

2.3. Individual Registrant Study Summaries

2.3.1. MRID 47815102[22]

The effect of Clarity 4.0 SL (AI: DGA Dicamba) on the vegetative vigor of monocot (corn, *Zea mays*; onion, *Allium cepa*; ryegrass, *Lolium perenne*; and wheat, *Triticum aestivum*) and dicot (cabbage, *Brassica oleracea*; carrot, *Daucus carota*; lettuce, *Lactuca sativa*; oilseed rape, *Brassica napus*; soybean, Glycine max; and tomato, *Lycopersicon esculentum*) crops was studied at measured test concentrations of <0.0178 (<LOQ, controls), 0.125, 0.260, 0.515, 1.02, and 2.02 lbs a.e./A (corn, onion, ryegrass, and wheat); <0.0178 (<LOQ, controls), 0.000261, 0.000751, 0.00227, 0.00676, 0.0196, and 0.0602 lbs a.e./A (soybean and tomato); <0.0178 (<LOQ, controls), 0.00816, 0.0241, 0.0703, 0.215, 0.647, and 2.07 lbs a.e./A (cabbage and carrot); <0.0183 (<LOQ, controls), 0.000262, 0.000766, 0.00225, 0.00697, 0.0210, and 0.0646 lbs a.e./A (lettuce); and <0.0183 (<LOQ, controls), 0.00851, 0.0254, 0.0739, 0.222, 0.661, and 2.08 lbs a.e./A (oilseed rape).

A surfactant and adjuvant was added to the spray solutions. This is considered part of the test material for an end-use product where it is recommended for use on the label. A surfactant, adjuvant and water alone treatment was included in the study, but comparisons were made against the water only control. The growth medium used in the vegetative vigor test was artificial soil (sandy loam, pH 6.0, organic carbon 0.9%).

On day 21 the surviving plants per pot were recorded and cut at soil level for measuring the plant height and dry weight. Survival, dry weight and height were significantly affected in all dicot and some monocot crops. The most sensitive monocot species was onion, based on dry weight, with EC_{05} and EC_{25} values of

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[22] MRID 47815102. Porch, J.R., Krueger, H.O., Kendall, T.Z., and Holmes, C. 2009. BAS 18309H (Clarity):A toxicity test to determine the effects of the test substance on vegetative vigor of ten species of plants. Unpublished study performed by Wildlife International, Ltd., Easton, Maryland. Laboratory study no.: 147-236. Study sponsored by BASF Corporation, Research Triangle Park, North Carolina. Sponsor study no.: 358586. Study completed June 30, 2009.

0.137 and 0.472 lbs a.e./A, respectively. The most sensitive dicot species was soybean, based on height, with EC_{05} and EC_{25} values of 0.00011 and 0.000513 lbs a.e./A, respectively. For onion, the NOAEC was above the EC_{25}, therefore the EC_{05} was also calculated. For soybean, the NOAEC was selected at the lowest tested concentration in the study based on arguments provided in USEPA 2013c[23]. As discussed in that memorandum, there was a 9% reduction in plant height at the 0.000261 lbs a.e./A concentration as compared to the controls.

Reported VSI included leaf curl, stem curl, chlorosis, and necrosis. There were no effects on ryegrass. Corn had scattered, mild effects that did not appear to be treatment-related. Species that were affected exhibited a dose-response relationship, the results for soybean are provided in **Figure C.1**. The regression equation provided was used to estimate the %VSI observed at the IC_{05} (0.00011 lbs a.e./A) for soybean based on height reduction. The result suggested 11% VSI at 5% height or a ratio of ~ 2:1.
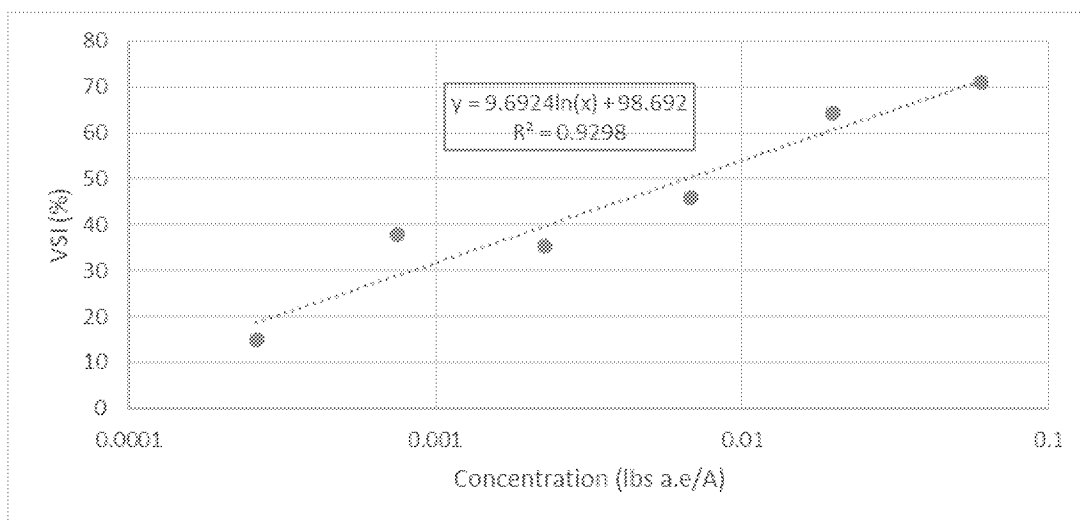
Figure C.1. Regression of soybean VSI against tested dose concentration.

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[23] USEPA 2013. Memorandum: Addendum to the Data Evaluation Report on the Toxicity of Clarity 4.0 SL (AI: Dicamba) to Terrestrial Vascular Plants: Vegetative Vigor (MRID 47815102).

Table C.2. MRID 47815102: Summary of most sensitive parameters by species (lbs ae/A),

| Species | Clarity (DGA) lbs a.e./A | | | | | |
| | MRID 47815102 | | | | | |
	Endpoint	NOAEC[1,2]	EC$_{25}$/IC$_{25}$	Endpoint	NOAEC[1,2]	EC$_{25}$/IC$_{25}$
Cabbage	Dry weight	0.0241	0.695	Height	0.647	-
Carrot	Dry weight	0.003622	0.0657	Height	0.215	-
Corn	Dry weight	2.02	>2.02	Height	2.02	>2.02
Oilseed Rape	Dry weight	0.0739	0.498	Height	0.661	1.33
Onion	Dry weight	0.137	0.472	Height	0.515	1.04
Ryegrass	Dry weight	2.02	>2.02	Height	2.02	>2.02
Wheat	Dry weight	0.08332	0.491	Height	0.26	>2.02
Tomato	Dry weight	0.0001322	0.000886	Height	0.000751	0.0029
Soybean	Dry weight	0.000121	0.0016	Height	**0.000261**	**0.000513**

[1] NOAECs that italicized are IC05s
[2] Bolded values are the most sensitive based on the IC25

2.3.2. MRID 48718015[24]

The effect of Dicamba (BAPMA salt) on the vegetative vigor of monocot (corn, Zea mays; onion, Allium cepa; ryegrass, Lolium perenne; and wheat, Triticum aestivum) and dicot (cabbage, Brassica oleracea; carrot, Daucus carota; lettuce, Lactuca sativa; oilseed rape, Brassica napus; soybean, Glycine max; and tomato, Lycopersicon esculentum) crops was studied at measured test concentrations of <0.000036 (negative and solvent control), 0.0224, 0.0661, 0.2113, 0.6241, and 1.9172 lbs ai/A (corn); <0.000036 (negative and solvent control), 0.024, 0.0721, 0.2111, 0.6474 and 1.9699 lbs ai/A (Onion, ryegrass, wheat); <0.000036 (negative and solvent control), 0.0027, 0.0082, 0.024, 0.0721, 0.2111 and 0.6474 lbs ai/A (Cabbage); <0.000036 (negative and solvent control), 0.0009, 0.0026, 0.0076, 0.0224, 0.0661 and 0.2113 lbs ai/A (Carrot); <0.000036 (negative and solvent control), 0.0003, 0.0027, 0.0082, 0.024, and 0.0721 lbs ai/A (Lettuce); <0.000036 (negative and solvent control), 0.0026, 0.0076, 0.0224, 0.0661, and 0.2113 lbs ai/A (Oilseed rape); <0.000036 (negative and solvent control), 0.0001, 0.0003, 0.0009, 0.0026, 0.0082 and 0.0245 lbs ai/A (Soybean); <0.000036 (negative and solvent control), 0.0003, 0.0009, 0.0026, 0.0076, and 0.0224 lbs ai/A (Tomato).

The growth medium used in the seedling emergence test was artificial soil (sandy loam, pH 6.2, organic matter 1.2%).

On day 21 the surviving plants per pot were recorded and cut at soil level for measuring the plant height and dry weight. Survival in the negative control ranged from 90-100%; Survival in the solvent control ranged from 80-100%. Inhibitions in height were maximums of 2% and 7% for ryegrass and carrot. The most sensitive monocot species was onion based on biomass, with NOAEC and EC25 values of 0.0721 and 0.0924 lb ai/A, respectively. The most sensitive dicot species was soybean based on height,

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[24] MRID 48718015. Porch, J.R., H.O. Krueger, and K.H. Martin. 2011. BAPMA formulation: A Toxicity Test to Determine the Effects on (Tier II) Vegetative Vigor of Ten Species of Plants. Unpublished study performed by Wildlife International, Ltd., Easton, Maryland. Study Project Number: 147-252. Study sponsored by BASF Corporation Agricultural Products Division, Research Triangle Park, North Carolina. Study completed December 14, 2011

with a NOAEC and EC25 values of 0.0001 and 0.000826 lb ai/A, respectively. These IC_{25}s are less sensitive than the regulatory endpoint based on soybean height (IC_{25} = 0.000513 lbs a.e./A; MRID 47815102).

VSI included adventitious growth, leaf curl, chlorosis, necrosis, and stem curl. Signs of phytotoxicity appeared dose-responsive and treatment related, increasing in severity and prevalence with an increase in treatment rate the results for soybean are provided in **Figure C.2**. The regression equation provided in **Figure C.2** was used to estimate the %VSI observed at the IC_{05} (0.00017 lbs a.e./A) for soybean based on height reduction. The result suggested 12% VSI at 5% height or a ratio of 2.5:1.
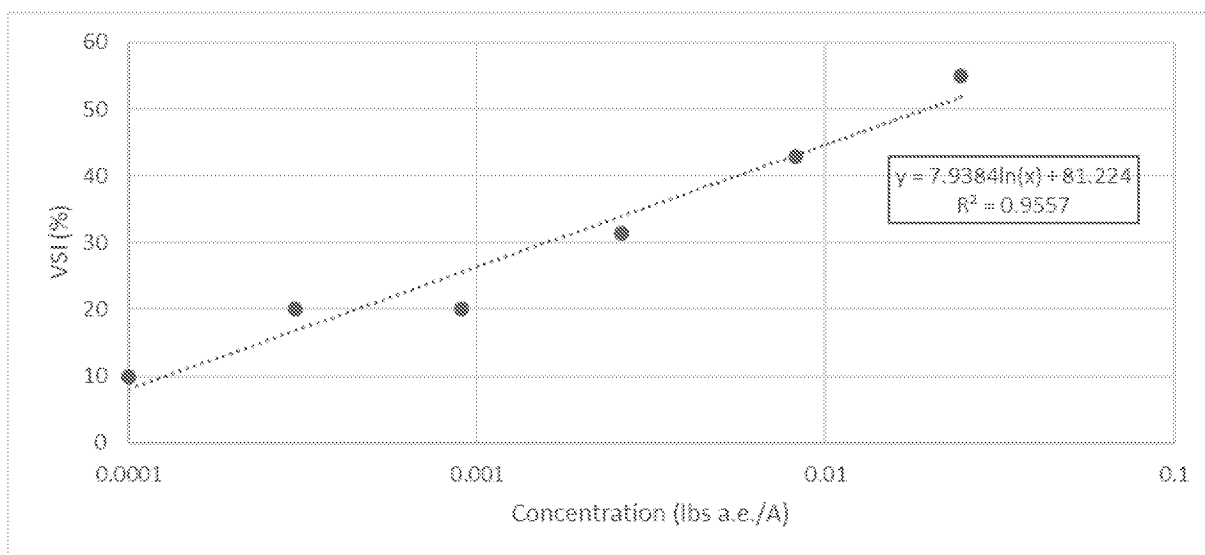
Figure C.2. Regression of soybean VSI against tested dose concentration.

Table C.3. MRID 48718015: Summary of most sensitive parameters by species (lbs ae/A)

Species	Endpoint	NOAEC[1,2]	EC25/IC25	Endpoint	NOAEC[1,2]	EC25/IC25
Cabbage	Dry weight	0.024	0.12	Height	0.6474	-
Carrot	Dry weight	0.0076	0.0343	Height	0.0322	6.76
Corn	Dry weight	0.0224	0.364	Height	0.0661	2.31
Lettuce	Dry weight	0.0082	0.0162	Height	0.024	-
Oilseed Rape	Dry weight	0.0661	0.125	Height	0.2113	-
Onion	Dry weight	0.0721	0.0924	Height	0.0721	0.293
Ryegrass	Dry weight	0.0721	2.42	Height	0.6474	35.1
Wheat	Dry weight	0.0721	0.272	Height	0.0721	1.44
Tomato	Dry weight	0.000922	0.00403	Height	0.0009	0.00247
Soybean	Dry weight	0.0000617	0.00137	Height	**0.0003**	**0.000826**

1 NOAECs that italicized are IC05s
2 Bolded values are the most sensitive based on the IC25

2.3.3. MRID 50102116[25]

The effect of A21472C formulation (Dicamba, 12.4% acid {17.7% dicamba DGA salt} + s-Metolachlor, 23.8%) on the vegetative vigor of monocot (corn, *Zea mays*; oat, *Avena sativa*; onion, *Allium cepa*; and ryegrass, *Lolium perenne*) and dicot (cabbage, *Brassica oleracea*; cucumber, *Cucumis sativa;* lettuce, *Lactuca sativa;* soybean, *Glycine max*; tomato, *Lycopersicon esculentum*; and turnip, *Brassica rapa*) crops was studied.

Concentrations of both Dicamba and s-Metolachlor were analytically measured and ranged from <0.000011 (<LOQ, negative control) to 0.63 lb ae/A of dicamba and <0.000022 (<LOQ, negative control) to 1.3 lb ai/A s-Metolachlor. The growth medium used in the vegetative vigor test was a loamy sand made from kaolinite clay, industrial quartz sand and peat, with limestone buffer added to buffer pH (loamy fine sand, pH 6.9, organic carbon 1.1%). On day 21, the surviving plants per pot were recorded and cut at soil level for measuring plant height and dry weight.

Negative control seedling survival was 100%. There were significant inhibitions in survival in cucumber, onion, and tomato. Significant inhibitions in seedling height were found in all species, except cabbage and ryegrass, and significant inhibitions in seedling dry weight in all species, except ryegrass. Based on the reviewer's results, the most sensitive monocot was onion, based on dry weight, with NOAEC, IC05 and IC25 values of <0.0025, 0.00262 and 0.0248 lb ae/A measured Dicamba concentrations, respectively (<0.0049, 0.00525 and 0.0497 lb ai/A measured s-Metolachlor, respectively); and the most sensitive dicot was tomato, based on dry weight, with NOAEC and IC25 values of 0.0010 and 0.00208 lb ae/A measured Dicamba, respectively (0.0020 and 0.00409 lb ai/A measured s-Metolachlor, respectively). These IC_{25}s are less sensitive than the regulatory endpoint based on soybean height (IC_{25} = 0.000513 lbs a.e./A; MRID 47815102).

Reported VSI included leaf curl, stem curl, chlorosis, and necrosis. The effects were dose-related in all species except oat and ryegrass. Control plants showed none to slight symptoms in all species, except for a single control onion plant that had moderate symptomology. The results for soybean are provided in **Figure C.3**. The regression equation provided in **Figure C.3** was used to estimate the %VSI observed at the IC_{05} (0.0025 lbs a.e./A) for soybean based on height reduction. The result suggested 40.3% VSI at 5% height or a ratio of ~ 8.1.

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[25] MRID 50102116. McKelvey, R.A., Keller, K. and J.R. Porch. 2017. S-Metolachlor and Dicamba (A21472C) - Toxicity Effects on the Vegetative Vigor of Ten Species of Plants. Final Report. Unpublished study performed by EAG Laboratories, Easton, Maryland. Study sponsored by Syngenta Crop Protection, LLC, Greensboro, North Carolina. Report/Study Number 528P-155. Study completed February 10, 2017.
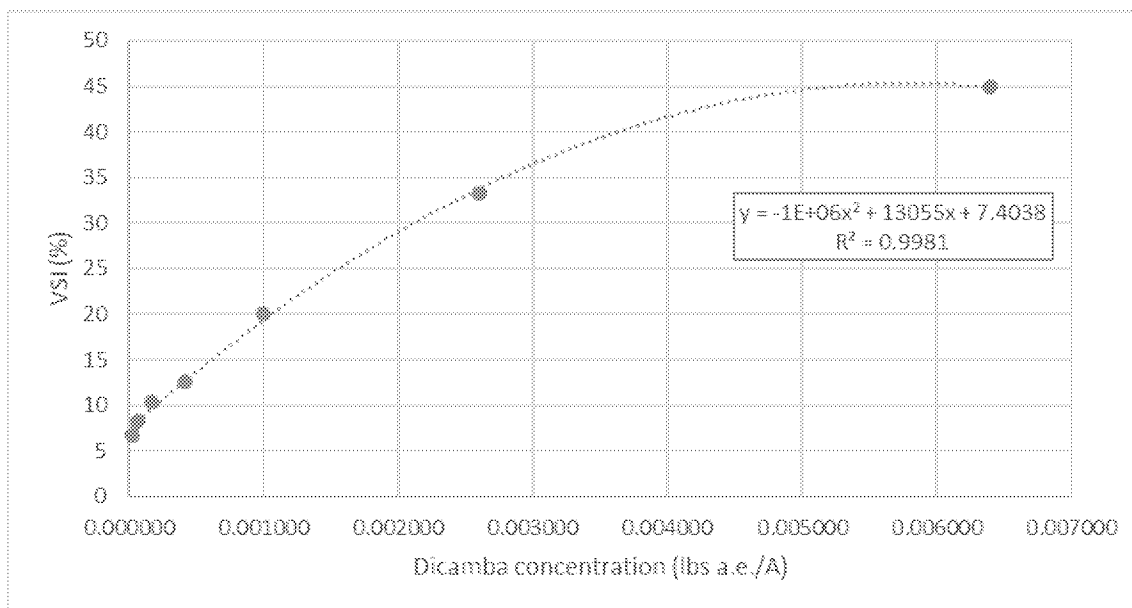
Figure C.3. Regression of soybean VSI against tested dose concentration.

The chart shows VSI (%) on the y-axis (0 to 50) versus Dicamba concentration (lbs a.e./A) on the x-axis (0.000000 to 0.007000), with fitted equation:

$$y = -1E+06x^2 + 13055x + 7.4038$$
$$R^2 = 0.9981$$

Table C.4. MRID 50102116: Summary of most sensitive parameters by species (lbs ae/A)

Species	Endpoint	NOAEC[1,2]	EC25/IC25	Endpoint	NOAEC[1,2]	EC25/IC25
Cabbage	Dry weight	0.0025	0.0618	Height	0.59	>0.59
Corn	Dry weight	0.24	0.501	Height	0.24	>0.59
Cucumber	Dry weight	0.0025	0.00536	Height	0.0025	0.0028
Lettuce	Dry weight	0.0026	0.0053	Height	0.00017	>0.016
Oat	Dry weight	0.1	>0.63	Height	0.1	>0.63
Onion	Dry weight	0.0026	0.0248	Height	0.039	0.256
Ryegrass	Dry weight	0.59	>0.59	Height	0.59	>0.59
Turnip	Dry weight	0.001	0.0171	Height	0.016	0.141
Tomato	Dry weight	**0.001**	**0.00208**	Height	0.0026	0.00524
Soybean	Dry weight	0.00042	0.0037	Height	0.0026	0.00605

1 NOAECs that italicized are IC05s
2 Bolded values are the most sensitive based on the IC25

2.4.1.1. MRID 49953901[26]

The effect of MON 76832 (Dicamba DGA + Glyphosate ethanolamine salt) on the vegetative vigor of dicot (soybean, *Glycine max;* and tomato, *Lycopersicon esculentum*) crops was studied. No monocots were studied. Concentrations of both Dicamba and Glyphosate were analytically confirmed at all

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[26] MRID 49953901. Orvos, A.R., J.R. Porch, and A. Siddiqui. 2016. MON 76832: A Toxicity Test to Determine the Effects on Easton, Maryland, USA, and sponsored by Monsanto Company, St. Louis, Missouri, USA. Wildlife International, Vegetative Vigor of Tomatoes and Soybeans. Unpublished study performed by Wildlife Project No. 139P-127; Monsanto Study No. MSL0027819.

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treatment levels, <0.00018 (LOQ, negative control), 0.00043, 0.00086, 0.0017, 0.0034, 0.0069, and 0.014 lb ae/A Dicamba acid, and <0.00018 (LOQ, negative control), 0.00084, 0.0017, 0.0033, 0.0065, 0.014, and 0.027 lb ae/A Glyphosate acid.

The growth medium used in the vegetative vigor test was a kaolinite clay, sand and peat mix (loamy sand, pH 6.9, organic carbon 1.1%). On day 21 the surviving plants per pot were recorded and cut at soil level for measuring the plant height and dry weight.

Survival in the negative control was 100%. There were no significant inhibitions in survival in the two dicots studied compared to the negative control (p>0.05). There were significant inhibitions in soybean and tomato seedling height compared to the negative control. Significant inhibitions in soybean height were 25, 31, 42 and 54% at 0.0017, 0.0034, 0.0069, and 0.014 lb ae/A Dicamba acid, respectively (0.0033, 0.0065, 0.014, and 0.027 lb ae/A Glyphosate acid) (Jonckheere-Terpstra Step-Down test, p<0.05). Significant inhibitions in tomato height were 13 and 50% at the 0.0069, and 0.014 lb ae/A Dicamba acid treatment levels, respectively (0.014 and 0.027 lb ae/A Glyphosate acid) (Dunnett's test, p<0.05).

There were also significant inhibitions in soybean and tomato dry weight compared to the negative control. The reviewer found significant inhibitions in soybean dry weight of 13, 26, 30, 41 and 51% at 0.00086, 0.0017, 0.0034, 0.0069, and 0.014 lb ae/A Dicamba acid (measured), respectively (0.0017, 0.0033, 0.0065, 0.014, and 0.027 lb ae/A Glyphosate acid), and in tomato dry weight of 9, 12, 24, 35, 48 and 60% at 0.00043, 0.00086, 0.0017, 0.0034, 0.0069, and 0.014 lb ae/A Dicamba acid (measured), respectively (0.00084, 0.0017, 0.0033, 0.0065, 0.014, and 0.027 lb ae/A Glyphosate acid) compared to the negative control (Williams test, p<0.05).

Based on the reviewer's vegetative vigor results, the most sensitive dicot species was tomato, based on dry weight, with NOAEC, IC_{05} and IC_{25} values of <0.00043, 0.000251 and 0.00191 lb ae/A Dicamba acid (measured), respectively, and <0.00084, 0.000488 and 0.00373 lb ae/A Glyphosate acid (measured), respectively. These IC_{25}s are less sensitive than the regulatory endpoint based on soybean height ($IC_{25} = 0.000513$ lbs a.e./A; MRID 47815102).

The occurrence of VSI (referred in the study report as "plant condition") was determined from observation. The severity of effects ranged from none to moderate VSI in soybean and tomato (≤64%). Phytotoxic effects included chlorosis, necrosis, leaf curl, and stem curl; phytotoxic effects exhibited a dose-response relationship. The results for soybean are provided in **Figure C.4**. The regression equation provided in **Figure C.4** was used to estimate the %VSI observed at the IC_{05} (0.00033 lbs a.e./A) for soybean based on height reduction. The result suggested 18.6% VSI at 5% height or a ratio of ~3.7.

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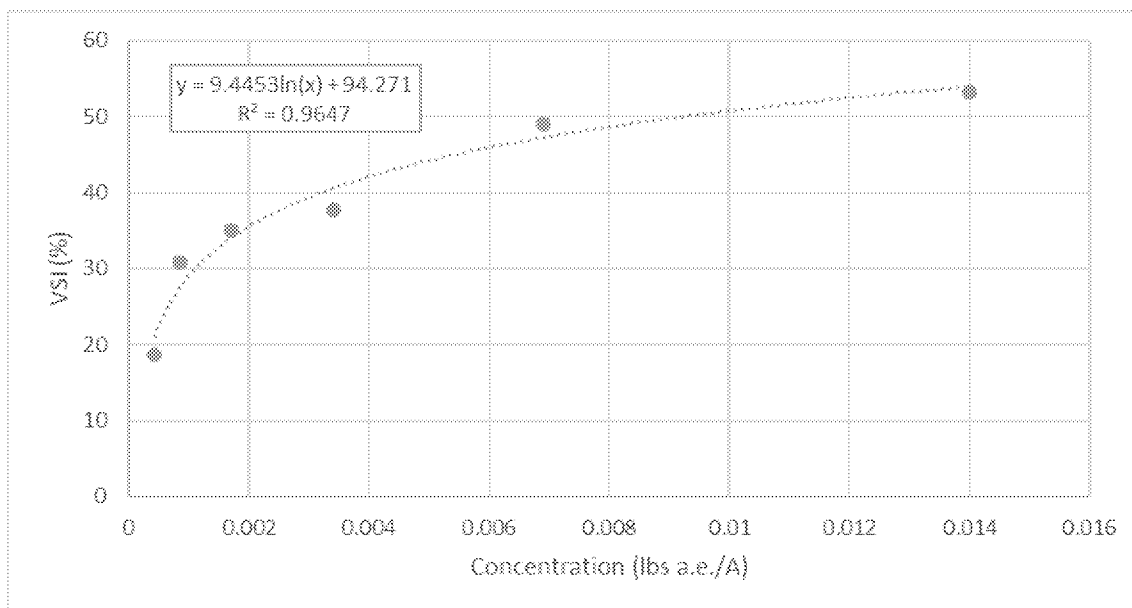
Figure C.4. Regression of soybean VSI against tested dose concentration.

Table C.5. MRID 49953901: Summary of most sensitive parameters by species (lbs ae/A),

| | Clarity (DGA+Glyphosate) lbs a.e./A | | | | | |
| | MRID 49953901 | | | | | |
Species	Endpoint	NOAEC[1,2]	EC$_{25}$/IC$_{25}$	Endpoint	NOAEC[1,2]	EC$_{25}$/IC$_{25}$
Tomato	Dry weight	**0.000251**	**0.00191**	Height	0.0033	0.0085
Soybean	Dry weight	0.00043	0.00214	Height	0.0008	0.0022

1 NOAECs that italicized are IC05s
2 Bolded values are the most sensitive based on the IC25

2.3.4. MRID 50103801

The effect of MON 76832 (Dicamba DGA + Glyphosate ethanolamine salt) on the vegetative vigor of monocot (corn, *Zea mays*; onion, *Allium cepa*; ryegrass, *Lolium perenne*; and wheat, *Triticum aestivum*), and dicot (cabbage, *Brassica oleracea*; carrot, *Daucus carota*; lettuce, *Lactuca sativa*; and oilseed rape, *Brassica napus*) crops was studied. Concentrations of both Dicamba and Glyphosate were analytically confirmed at all treatment levels, and corresponding measured concentrations were <0.00014 (LOQ, negative control), 0.00023, 0.00068, 0.0021, 0.0064, 0.019, 0.057, 0.17, and 0.50 lb ae/A Dicamba acid (cabbage, carrot, lettuce and oilseed rape); <0.00014 (LOQ, negative control), 0.00022, 0.00067, 0.0020, 0.0060, 0.018, 0.055, 0.16, 0.49, and 1.4 lb ae/A Dicamba acid (corn, onion, ryegrass, and wheat); <0.00018 (LOQ, negative control), 0.00042, 0.0013, 0.0037, 0.012, 0.035, 0.11, 0.32, and 0.97 lb ae/A Glyphosate acid (cabbage, carrot, lettuce and oilseed rape); and <0.00018 (LOQ, negative control), 0.00042, 0.0013, 0.0038, 0.012, 0.035, 0.11, 0.33, 1.0, and 3.3 lb ae/A Glyphosate acid (corn, onion, ryegrass, and wheat).

The growth medium used in the vegetative vigor test was a kaolinite clay, sand and peat mix (loamy sand, pH 6.9, organic carbon 1.1%). On day 21 the surviving plants per pot were recorded and cut at soil level for measuring the plant height and dry weight.

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Survival in the negative control was 97-100%. The reviewer found significant inhibitions in survival in all species tested compared to the negative control. Significant survival inhibitions in carrot were 10 and 40%, and in lettuce were 28 and 72%, at 0.057 and 0.17 lb ae/A Dicamba acid measured concentrations, respectively (0.11 and 0.32 lb ae/A Glyphosate acid); significant survival inhibitions in ryegrass were 33, 67, and 93% at 0.16, 0.49, and 1.4 lb ae/A Dicamba acid, respectively (0.33, 1.0, and 3.3 lb ae/A Glyphosate acid); Jonckheere-Terpstra Step-Down test, $p < 0.05$. Significant decreases in corn survival of 23 and 93% were found at 0.055 and 0.16 lb ae/A Dicamba acid, respectively (0.11 and 0.33 lb ae/A Glyphosate acid), and significant decreases in cabbage survival of 23 and 73% were found at 0.17 and 0.50 lb ae/A Dicamba acid measured concentrations, respectively (0.32 and 0.97 lb ae/A Glyphosate acid measured concentrations); Mann-Whitney U Two-Sample test, $p < 0.05$. In addition, significant inhibitions in oilseed rape, onion, and wheat survival were 50, 23 and 90% at 0.16/0.17 lb ae/A Dicamba acid measured concentrations, respectively, (0.32/0.33 lb ae/A Glyphosate acid measured concentrations), compared to the negative control; Mann-Whitney U Two-Sample test, $p < 0.05$.

Significant inhibitions in seedling height were also found in all species tested compared to the negative control. Significant inhibitions in carrot height were 10, 48 and 68%, in lettuce height were 22, 67, and 76%, and in wheat height were 6, 39, and 57% at 0.18/0.019, 0.055/0.057, and 0.16/0.17 lb ae/A measured Dicamba acid, respectively (0.035, 0.11 and 0.32/0.33 lb ae/A measured Glyphosate acid); Williams test, $p < 0.05$. Significant inhibitions in corn height were 54 and 75%, and in oilseed rape height were 19 and 74%, at 0.055/0.057 and 0.16/0.17 lb ae/A measured Dicamba acid, respectively (0.11 and 0.32/0.33 lb ae/A measured Glyphosate acid); significant inhibition in cabbage height was 35, 63, and 68% at 0.057, 0.17, and 0.50 lb ae/A Dicamba acid measured concentrations, respectively (0.11, 0.32, and 0.97 lb ae/A measured Glyphosate acid);Williams test, $p < 0.05$. In addition, significant decreases in onion height of 29 and 60% were found at 0.055 and 0.16 lb ae/A Dicamba acid measured concentrations, respectively (0.11 and 0.33 lb ae/A Glyphosate acid), and significant decreases in ryegrass height of 15, 54, 66, and 57% were found at 0.055, 0.16, 0.49, and 1.4 lb ae/A Dicamba acid measured concentrations, respectively (0.11, 0.33, 1.0, and 3.3 lb ae/A Glyphosate acid measured concentrations) compared to the negative control (Jonckheere-Terpstra Step-Down test, $p < 0.05$.

The reviewer also found significant inhibitions in seedling dry weight in all species tested compared to the negative control. Significant inhibitions in corn dry weight were 20, 75, and 95% at 0.018, 0.055 and 0.16 lb ae/A Dicamba acid measured concentrations, respectively (0.035, 0.11 and 0.33 lb ae/A Glyphosate acid measured concentrations); significant inhibitions in onion dry weight were 59 and 75%, and in wheat dry weight were 76 and 94%, at 0.055 and 0.16 lb ae/A Dicamba acid measured concentrations, respectively (0.11 and 0.33 lb ae/A Glyphosate acid measured concentration); Williams test, $p < 0.05$). For oilseed rape dry weight significant inhibitions were 13, 12, 24, 72, and 95%, at 0.0021, 0.0064, 0.019, 0.057 and 0.17 lb ae/A Dicamba acid measured concentrations, respectively (0.0037, 0.012, 0.035, 0.11 and 0.32 lb ae/A Glyphosate acid measured concentrations); Jonckheere-Terpstra Step-Down test, $p < 0.05$. Significant decreases in carrot dry weight were 18, 31, 83, and 90% at 0.0064, 0.019, 0.057 and 0.17 lb ae/A Dicamba acid measured concentrations (0.012, 0.035, 0.11 and 0.32 lb ae/A Glyphosate acid measured concentrations); in cabbage dry weight were 18, 78, 93, and 94% at 0.019, 0.057, 0.17, and 0.50 lb ae/A Dicamba acid measured concentrations (0.035, 0.11, 0.32, and 0.97 lb ae/A Glyphosate acid measured concentrations); and in ryegrass dry weight were 46, 88, 92, and 92% at 0.055, 0.16, 0.49, and 1.4 lb ae/A Dicamba acid measured concentrations (0.11, 0.33, 1.0, and 3.3 lb ae/A Glyphosate acid measured concentrations), respectively, compared to the negative control (Jonckheere-Terpstra Step-Down test, $p < 0.05$).

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For lettuce dry weight, significant inhibitions were 19, 35, 69, 91, and 95%, at 0.0021, 0.0064, 0.019, 0.057 and 0.17 lb ae/A measured dicamba acid (0.012, 0.035, 0.11 and 0.32 lb ae/A glyphosate acid);Jonchkeere-Terpstra Step-Down Test, $p<0.05$. However, it should be noted that although the 19% inhibition at the 0.0021 lb ae/A dicamba acid application rate was found to be statistically significant, the 20% inhibition found at the next lowest dose (0.00068 lb ae/A dicamba acid) was not statistically significant, likely due to slightly higher variability (Jonchkeere-Terpstra Step-Down Test, p = 0.12, CV of 38.3%). As the observed effects in these two concentrations were essentially the same, the reviewer determined that the biological NOAEC should therefore be established at the 0.00023 lb ae/A dicamba acid concentration (0.00042 lb ae/A glyphosate acid) and the LOAEC should therefore be considered the 0.00068 lb ae/A dicamba acid concentration (0.0013 lb ae/A glyphosate acid).

Based on the reviewer's results, the most sensitive monocot was wheat, based on dry weight, with NOAEC, IC_{05} and IC_{25} values in terms of measured Dicamba acid concentrations of 0.018, 0.0118 and 0.0221 lb ae/A, and in terms of Glyphosate acid measured concentrations of 0.035, 0.0228 and 0.0432 lb ae/A, respectively. However, as these values indicate that the statistical wheat NOAEC and IC_{25} endpoints are essentially indistinguishable, the reviewer finds that the regression-based IC_{05} would be more appropriate for quantitative use in risk assessment and be more likely to be protective of risks to listed species, rather than the NOAEC. The most sensitive dicot was lettuce, based on dry weight, with NOAEC and IC_{25} values in terms of measured Dicamba acid concentrations of 0.00023 and 0.00223 lb ae/A, respectively, and in terms of Glyphosate acid measured concentrations of 0.00042 and 0.00398 lb ae/A, respectively. These IC_{25}s are less sensitive than the regulatory endpoint based on soybean height (IC_{25} = 0.000513 lbs a.e./A; MRID 47815102).

The occurrence of VSI (referred in the study report as "plant condition") was determined from observation. The severity of effects ranged from none to severe effects in all species tested, including plant death in all species. Phytotoxic effects included chlorosis, necrosis, and leaf curl; phytotoxic effects exhibited a dose-response relationship. Because soybean was not included in this study, no regressions of VSI were generated by the reviewer.

Table C.6. MRID 50103801: Summary of most sensitive parameters by species (lbs ae/A),

Species	Endpoint	NOAEC[1,2]	EC_{25}/IC_{25}	Endpoint	NOAEC[1,2]	EC_{25}/IC_{25}
Cabbage	Dry weight	0.0064	0.0211	Height	0.035	0.077
Carrot	Dry weight	0.0021	0.016	Height	0.012	0.0617
Corn	Dry weight	0.006	0.0246	Height	0.035	0.063
Lettuce	Dry weight	**0.00023**	**0.00223**	Height	0.012	0.034
Oilseed Rape	Dry weight	0.00068	0.0221	Height	0.035	0.125
Onion	Dry weight	0.007052	0.0244	Height	0.035	0.106
Ryegrass	Dry weight	0.018	0.0311	Height	0.035	0.114
Wheat	Dry weight	0.01182	0.0221	Height	0.012	0.0747

1 NOAECs that italicized are IC05s
2 Bolded values are the most sensitive based on the IC25

2.3.5. MRID 51068202

The effect of MON 54140 (a.i. Dicamba diglycolamine (DGA) salt) + Induce surfactant on the vegetative vigor of trees (Apple, *Malus domestica*; Cherry, *Prunus avium;* London plane, *Plantanus acerifolia*; American red oak, *Quercus rubra*; and Swamp cypress, *Taxodium distichum*) was studied at a nominal test concentration of 0.000513 lb ae/A Dicamba in a Tier I test. The concentration of the spray application solution was not analytically confirmed. The growth medium used in the test was standard "Riedberg" soil sieved to 2 mm (silt loam; pH 6.77 ($CaCl_2$); organic carbon 0.72%). On 90 days after application, the saplings were cut at soil level for measuring the plant height and dry weight.

Negative control survival was 100% for all species and there were no significant decreases in survival compared to the negative control for any species tested. When compared to the negative control, significant inhibitions in plant height were observed in the treatment group for apple (4% reduction) and American red oak (11% reduction) saplings. The reviewer found no significant inhibitions in sapling dry weight compared to the control for all species tested.

Therefore, the resulting NOAEC values were <0.000513 lb ae/A for apple and American red oak height; and 0.000513 lb ae/A for all other sapling species and endpoints.

The following phytotoxic symptoms were noted: chlorosis, necrosis, deformation/epinasty, and reddening. Slight phytotoxic symptoms were observed in all species.

The significant inhibitions in apple and American red oak height when compared to the negative control were ≤25% at 0.000513 lbs a.e./A. Therefore, their potential IC25s are expected to be less sensitive than the regulatory endpoint based on soybean height (IC_{25} = 0.000513 lbs a.e./A; MRID 47815102).

2.4. Open literature studies

2.4.1. Silva et al. (2018[27])

Silva et al. (2018) was reviewed to make comparisons of height and yield with VSI. In this field trial, dicamba was directly applied to dicamba sensitive soybean at 0, 3.7, 7.4, 14.9 and 29.8 g a.e./ha. Spray applications were made at the V5 or R2 growth stages in separate experiments. VSI were assessed at four weeks after treatment on a 0 to 100% scale relative to untreated plots (method/scale used for injury was not reported). In addition, five random plants in each treatment were selected for soybean height, which measured distance from the ground to the tip of the topmost fully expanded leaf. At harvest, the two center rows of each plot were harvested manually and grain yield (total grain weight) was recorded and normalized to a constant water content. Application rate was regressed against VSI, height and yield. From these regressions, an estimated dicamba treatment corresponding to a 5% yield reduction at harvest and 5% reduction in plant height are provided in **Table C.7**.

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[27] **MRID 50706301**. Silva, D.R.O., E.D.N. Silva, A.C.M. Aquiar, B.D.P. Novello, A.A.A. Silva, C.J. Basso (2018) Drift of 2,4-D and dicamba applied to soybean at vegetative and reproductive growth stage. Ciencia Rural, Santa Maria, 48: 1-8. https://dx.doi.org/10.1590/0103-8478cr20180179.

Table C.7. MRID 50706301: Height and Yield Endpoints and the Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	IC_{05} lbs a.e./A	%VSI at IC_{05}	Ratio VSI:IC_{05}
Plant Height – Vegetative Exposure	0.000767	34	6.7
Plant Height - Reproductive Exposure	0.0000401	4	0.9
Plant Yield Vegetative Exposure	0.0031	52	10.4
Plant Yield Reproductive Exposure	0.00092	11	2.2

2.4.2. Foster and Griffin (2018[28])

The Foster and Griffin field study evaluated the impact on non-dicamba resistant soybean (three cultivars: Pioneer 94Y80, Terral REV 51R53, and Asgrow 4835, one for each of the three years of the experiment) from direct spraying of dicamba. The dicamba DGA salt (Clarity® herbicide; BASF Corp., Research Triangle Park, NC) was applied to soybean at V3/V4 (third/fourth node with two to three fully expanded trifoliates) or at R1/R2 (open flower at any node on main stem/open flower at one of the two uppermost nodes on main stem). Dicamba rates included 0.6, 1.1, 2.2, 4.4, 8.8, 17.5, 35, 70, 140, and 280 g ae/ha (1/1,000 to 1/2 of the manufacturer's use rate of 560 g/ha). Nonionic surfactant at 0.25% vol/vol was added to all treatments, and a nontreated control was included for comparison. A randomized complete block design with a factorial arrangement of treatments (growth stage by dicamba rate) and four replications were used each year. Plants were evaluated for %VSI and percent reduced height at 7 and 15 days after treatment (DAT), mature plant height prior to harvest, and grain yield (moisture adjusted) at harvest. While the manuscript did not provide 5% effect levels, EPA used the equations that were provided in the manuscript to estimate the concentration causing a 5% effect on mature plant height and grain yield.

Table C.8. MRID 50706001: Foster and Griffin (2018): Height and Yield Endpoints and the Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	IC_{05} lbs a.e./A	%VSI at IC_{05}	Ratio VSI:IC_{05}
Plant Height – Vegetative Exposure	0.0018	47.0	9.4
Plant Height - Reproductive Exposure	0.0099	46.6	9.3
Plant Yield Vegetative Exposure	0.0021	47.4	9.5
Plant Yield Reproductive Exposure	0.0011	33.7	6.7

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[28] **MRID 50706001.** Foster, M.R. and J.L. Griffin (2018) Injury Criteria Associated with Soybean Exposure to Dicamba. Weed Technol. doi: 10.1017/wet.2018.42.

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2.4.3. Kniss (2018[29])

Kniss (2018) provided information related to soybean exposures associated with a 5% yield loss for soybeans. The analysis encompassed 11 primary publications and spanned the years 1978 to 2016. As expected based on the considerations discussed above regarding exposure timing effects on yield, the reproductive phases of soybean exposure were more sensitive than the vegetative phases, with R1 to R2 exposures of 0.15 to 14 g/ha (1.34 x10-4 to 1.25 x10-2 lb a.e./A) producing 5% yield loss with an across study pooled mixed model estimate of 5% yield effect value of 0.89 g/ha (7.94 x10-4 lb a.e./A). This estimate approaches the listed species endpoint used in the effects determinations (0.00026 lb ae/A). Vegetative phases V1 to V3 exhibited 5% yield loss at dicamba exposures ranging from 1.6 to 24 g/ha (1.43 x 10-3 to 2.14 x10-2 lb a.e./A) with a pooled across study mixed model estimate of 1.9 g/ha. Growth stages V4 to V7 showed 5% yield loss at an exposure ranging from 1.2 g/ha to 47 g/ha (1.07 x 10-3 to 4.19 x 10-2 lb a.e./A) with a pooled across study mixed model estimate of 5.7 g/ha (5.26 x 10-3 lb a.e./A

Table C.9. Kniss (2018): Height and Yield Endpoints and the Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	%VSI at IC_{05}	Ratio VSI:IC_{05}
Plant Yield Reproductive Exposure	18	3.6
Plant Yield Reproductive Exposure	11	2.2
Plant Yield Reproductive Exposure	10	2.0
Plant Yield Reproductive Exposure	12	2.4

2.4.4. Robinson et al. (2013[30])

Robinson et al. (2013) conducted field experiments at the Dow AgroSciences Midwest Research Center (MRC) near Fowler, IN in 2009. The authors planted Beck's brand '342NRR' soybeans in 38-cm rows at a density of 430,000 seeds/ha. Dicamba (diglycolamine salt) was applied at rates of 0, 0.06, 0.2, 0.6, 1.1, 2.3, 4.5, 9.1, and 22.7 g/ha at V2, V5, or R2 soybean growth stages. The applications were made to plots which were 3.1 m wide and 9.1 m long and consisted of a 3.1-m-long and 1.5-m-wide buffer to reduce the possibility of off-target movement into adjacent plots. All dicamba treatments were applied in 140 L/ha carrier volume using a CO2-pressurized backpack sprayer with a 3.1 m-wide boom and XR11002 flat fan nozzles (TeeJet Spraying Systems Company, Wheaton, IL 60189) at 138 kPa. Wind speeds at application were less than 5 km/h. The authors reported visual estimates of percentage of soybean injury at 14 and 28 DAT using a scale of 0 to 100%, where 0% = no crop injury and 100% = complete plant death (no additional details were provided). Plant height was also reported based on three plants sampled at the R8 growth stage. Additionally, 10 plants from the middle two rows of each treatment were arbitrarily selected to determine the following reproduction endpoints: yield (seed mass g/100 seeds), #seeds/m, #seeds/pod, #pods/m, #main-stem reproductive nodes/m, #pods/reproductive node, #mainstem nodes/m, and percentage of reproductive nodes. Plants were harvested with a plot combine and seed yield was adjusted to 13% moisture. Oil and protein concentrations were determined from

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[29]**MRID 50706401**. Kniss, A. (2018) Soybean Response to Dicamba: A Meta Analysis. Updated August 23 2018-version of manuscript accepted for publication in weed technology. https://plantoutofplace.com/2018/05/soybean-response-to-dicamba-a-meta-analysis/.

[30] Robinson, A.P., D.M. Simpson, and W.G. Johnson. 2013. Response of glyphosate-tolerant soybean yield components to dicamba exposure. Weed Science 61: 526-536

machine-harvested seed using near-infrared reflectance spectroscopy at the Purdue University Grain Quality Laboratory.

EPA's review of the study results focused on the reported yield effects and their relationship to VSI. The regression equations provided in Figure 5 of the study provided sufficient information to estimate the VSI to plant yield ratio (**Table C.10**). These results reflect the combination of the study sites presented in the study, however the individual study sites result in similar relationships and support the combined analyses presented.

Table C.10. Robinson et al. (2013): Height and Yield Endpoints and the Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	%VSI at IC_{05}	Ratio VSI:IC_{05}
Plant Yield Reproductive Exposure	19.9	4.0

2.4.5. Growe (2017[31])

Growe (2017) evaluated the effects of sub-lethal rates of dicamba on five maturity group VI soybean cultivars at vegetative and reproductive growth stages. The design was a factorial arrangement of 80 treatments in a randomized complete block with four replications and three factors consisting of dicamba rate, soybean cultivar, and soybean growth stage. Trials were conducted near Kinston, Lewiston, and Rocky Mount, NC. In each trial, five soybean varieties were planted using a two-row cone planter. The DGA salt formulation of dicamba (Clarity) was applied to soybean at 1.1, 2.2, 4.4, 8.8, 17.5, 35, and 70 g/ha (1/512 to 1/8 of the labeled 560 g/ha use rate for weed control in dicamba-tolerant soybean) when soybeans reached V4 (three completely unrolled trifoliates) or R2 (full bloom) growth stages. A non-treated control was included for each variety. Plot dimensions were 3.65 m wide by 9 m long. After each application, effects of dicamba were determined by collecting visual injury ratings at 7, 14, and 28 DAT using a scale of 0 (no injury) to 100% (complete death). Soybean height was recorded 0, 14, and 28 DAT by randomly selecting four plants from each plot and measuring from the soil surface to the terminal bud. The treated rows for each plot were mechanically harvested and yields were adjusted to 13% moisture.

While the manuscript did not provide 5% effect levels, EPA used the equations that were provided in the manuscript to estimate the concentration causing a 5% effect on mature plant height and grain yield (**Table C.11**).

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[31] **MRID 50707001**. Growe, A. (2017) Effects of Simulated Dicamba Drift on Maturity Group V and VI Soybean Growth and Yield. Thesis and Dissertation.

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Table C.11. Growe (2017): Height and Yield Endpoints and the Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	IC_{05} lbs a.e./A	%VSI at IC_{05}	Ratio VSI:IC_{05}
Plant Height – Kinston Vegetative Exposure	0.0029	16.1	3.2
Plant Height – Kinston Reproductive Exposure	0.0037	20.6	4.1
Plant Height – Lewiston Vegetative Exposure	0.0038	21.3	4.3
Plant Height – Lewiston Reproductive Exposure	0.0051	28.5	5.7
Plant Height – Rocky Mt Vegetative Exposure	0.00085	4.8	1.0
Plant Height – Rocky Mt Reproductive Exposure	0.0019	10.4	2.1
Plant Yield - Combined Vegetative Exposure	0.0018	10.1	2.0
Plant Yield - Combined Reproductive Exposure	0.0014	7.6	1.5
Plant Yield - Kingston Combined Exposure	0.0015	8.6	1.7
Plant Yield - Lewiston Combined Exposure	0.0021	12.0	2.4
Plant Yield – Rocky Mt. Combined Exposure	0.0023	12.7	2.5

Growe (2017) also reported results of another dose-based study (chapter 2). However, the results of this study were not presented in a format to discern the height data from vegetative stage exposures from those following reproductive stage exposures. Therefore, EPA excluded the chapter 2 results from further review.

2.4.6. Jones (2018[32])

Jones (2018, Chapter 1) evaluated the impact on non-dicamba resistant soybean from nearby dicamba applications, such as those made to nearby dicamba tolerant soybean and cotton in a series of separate but interrelated experiments (presented in separate chapters). Presented in Chapter 1 are the results of twenty-five field experiments conducted in 2014 and 2015 in Keiser and Marianna, Arkansas. These experiments were conducted using Clarity® (BASF Corporation) at 560 g a.e./ha (maximum labeled field rate for over the top application) applied during the reproductive stages of R1 through R6. Plots extended along transects until no injury was observed or the end of the field was reached. Soybean injury and three canopy heights were recorded at 28 DAA for each plot. A visual scale from 0 to 100%, with 100% being plant death, was used to estimate soybean injury (no further details on the visual scale method were provided). The percent of pods malformed and the height to the terminal of three individual plants per plot were recorded at soybean maturity. Additionally, a small-plot combine was

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[32] **MRID 50706101.** Jones, G.T. (2018) Evaluation of Dicamba Off-Target Movement and Subsequent Effects on Soybean Offspring. Theses and Dissertations. 2667. http://scholarworks.uark.edu/etd/2667.

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used to harvest plots, and grain yields (based on weight) were corrected to 13% moisture before being converted to a percentage yield relative to uninjured plots.

EPA reviewed these data to explore the ratio of VSI to percent yield reduction at the 5% threshold. EPA focused only on trials that investigated R1 & R2 (reproductive) plant growth stage exposures. EPA used plant height reduction, percent yield reduction and percent injury regression equations, provided by Jones, to estimate the corresponding level of visual injury that was observed at the same distance as 5% reduction of height or yield. This established a ratio of visual injury percentage to 5% reduction in height or yield. The average ratios for all trials was 3.5:1 (0.0-9.2 to 1) for VSI to height, and 5.1:1 (0.0-8.8 to 1) for VSI to yield.

Table C.12. Jones (2018): Height and Yield Endpoints and the Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	%VSI at IC_{05} Height	Ratio VSI:IC_{05}	%VSI at IC_{05} Yield	Ratio VSI:IC_{05}
Trial 1 – R1	22.4	4.5	35.9	7.2
Trial 2 – R1	9.0	1.8	35.5	7.1
Trial 3 – R1	12.0	2.4	32.2	6.4
Trial 4 – R1	14.6	2.9	41.8	8.4
Trial 5 – R1	13.8	2.8	35.8	7.2
Trial 6 – R1	1.8	0.4	10.6	2.1
Trial 7 – R2	0.0	0.0	2.9	0.6
Trial 8 – R2	12.6	2.5	27.2	5.4
Trial 9 – R2	23.4	4.7	NA	NA
Trial 10 – R2	45.8	9.2	44.5	8.9
Trial 11 – R2	38.2	7.6	0.0	0.0

2.4.7. Knezevic et al. 2018[33]

The Knezevic field study evaluated the impact on tomato and grape plants after direct spraying of dicamba (three different formulations) in the field. Tomatoes and grapes were treated at five different rates (0.56, 1.12, 5.6, 11.2, 56 g ae/ha, equivalent to 0.00050, 0.0010, 0.0050, 0.010, 0.50 lbs a.e./A) of three dicamba-based products (Clarity, Engenia, and XtendiMax). Each species of plant was treated at two different stages of growth (based on tomato height and grape vine length). Separate experiments were conducted over two years. Plants were evaluated for severity of % injury (7, 14, 21, and 28 days after treatment (DAT)), tomato height/grape vine length (14 and 28 DAT), and plant biomass (14 and 28 DAT). Analysis of the data calculated the Effective Dose (ED) at 10, 20 and 50 % effect for each measured variable.

Length (i.e., tomato shoot height and grape vine length), was analyzed by the study author in terms of individual dicamba products. However, biomass estimates were combined across products in the study report. EPA estimated 5% and 25% Inhibition Concentrations (IC05 and IC25) values to compare with results from registrant-submitted toxicity studies on dicamba. Regressions were carried out in Excel

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[33] **MRID 50706201**.Knezevic, S.Z., O.A. Osipitan, and J.E. Scott (2018) Sensitivity of Grape and Tomato to Micro-rates of Dicamba-based Herbicides. Journal of Horticulture, 5:229, doi: 10.4172/2376-0354.1000229

using linear, exponential, and power regression of the reported EDx values for length and biomass. Linear regressions (intercept set to zero) were generally judged poor fits and were therefore excluded as reviewer calculated IC05 values typically exceeded the reported ED10 values. The power and logistic regressions each fit the data well (r2 > 0.98), and the power regression results were selected based on their r-squared estimates.

Based on comparisons of the tomato height DGA and BAPMA IC25s, Knezevic et al. (2018) results (IC25s = 0.0014 and 0.0023 lbs a.e./A for DGA and BAPMA, respectively) are more sensitive than the height endpoints reported for both DGA (0.00290 lbs a.e./A) and BAPMA (0.00247 lbs a.e./A) in greenhouse studies using tomato (MRIDs 47815102 and 48718015 respectively). The corresponding tomato IC05 height estimates for Knezevic et al. (2018; DGA IC05 = 0.000077 lbs a.e./A; BAPMA IC05 = 0.000491 lbs a.e./A) were also more sensitive than the greenhouse tomato IC05 (0.000580 lbs a.e./A) for DGA and is slightly higher than the BAPMA estimate (IC05 = 0.000344 lbs a.e./A).

Because the biomass ICx estimates were based on the combined results from multiple experiments and are not specific to DGA or BAPMA, it is not possible to directly compare against the DGA and BAPMA products individually. However, the reviewer's IC25 estimate (0.00164 lbs a.e./A) suggest that the tomato biomass IC25 for DGA in the registrant submitted greenhouse study (0.000526 lbs a.e./A) was more sensitive (MRID 47815102). The registrant submitted BAPMA IC_{25} for biomass was 0.00403 lbs a.e./A. Therefore, the combination of DGA and BAPMA data in Knezevic et al. (2018) likely represents a similar distribution of effects, adding to uncertainty in the relative sensitivity in comparison to the DGA greenhouse result.

The results for grape indicate that based on the observed dicamba effects on vine length and biomass, the tomato was more sensitive of the two crops.

In comparison to the regulatory endpoint based on soybean height (IC_{25} = 0.000513 lbs a.e./A; MRID 47815102)., the Knezevic IC25 estimates are less sensitive in terms of the IC25.

3. Yield Studies

3.1. Registrant Submitted Studies

This appendix section describes the results from several soybean field toxicity studies conducted in 2019 and submitted to EPA. The purpose of the study designs was to examine the relationships and relative sensitivities of plant height, yield, and VSI. The studies applied a tank mixture solution of Clarity® formulation (a.i. Dicamba DGA salt) + Roundup PowerMAX® formulation (a.i. Glyphosate potassium salt) + Intact™ (drift reduction agent) on the growth and reproduction of a dicamba non-tolerant/glyphosate-tolerant soybean (*Glycine max*) crop. The studies targeted application during two developmental growth stages, early vegetative growth stage (V4) and flowering reproductive stage (R2). The treatment fields were divided into two equal fields with 24 replicate plots for each test; non-dicamba tolerant soybeans. Soybean plants were measured for height and assessed for visual morphology 14 and 28 days after treatment (DAT). Soybean plants were later harvested for determination of yield for both vegetative and reproductive stage exposure studies.

3.1.1. Results Synopsis

In each study, plant height and VSI followed an expected dose response pattern of increased VSI and decreased plant height when plants were exposed to progressively higher doses. Three of the four studies conducted in Missouri did not have reductions in yield when compared to controls. Of the other 7 available yield studies showed dose response reductions in yield as compared to the controls. Based on the observations on 28DAT, the IC25s for height and yield reflect similar sensitivities (within a factor of 2x). The studies also show similar sensitivity of yield and height when exposure occurs at the vegetative or reproductive growth stage. Based on these lines of evidence it was determined that plant height is a reasonable surrogate for yield.

In terms of VSI, the 14DAT observations were often more severe than at 28DAT for the same plots, suggesting that there was some recovery of the plants between the two observations. However, this was not considered a substantial trend and in some cases there was increasing VSI over that same interval.

Table C.13. Summary of Plant Height, Yield and VSI Endpoints derived from several field toxicity studies.

Location MRID	Growth Stage and Date	Endpoint	NOAEC	EC$_{05}$/IC$_{05}$	EC$_{25}$/IC$_{25}$	% VSI at NOAEC	%VSI at EC$_{05}$/IC$_{05}$	%VSI at EC$_{25}$/IC$_{25}$
Greenville, Mississippi MRID 51017504	Vegetative Growth (June 27, 2019)	14-DAT Height	<0.00031	0.000348	0.0017	14[b]	19	34
		28-DAT Height	<0.00031	0.000219	0.00207	15[b]	8	37
		Yield	0.00031	0.0005	0.026	14 (14DAT)	21 (14DAT)	58 (14DAT)
						15 (28DAT)	19 (28DAT)	71 (28DAT)
	Reproductive (July 11, 2019)	14-DAT Height	0.00059	0.000304	0.00236	27	19	44
		28-DAT Height	<0.00032	0.000236	0.00163	14[b]	7	42
		Yield	0.00059	0.00136	0.007	28 (14DAT)	37 (14DAT)	57 (14DAT)
						21 (28DAT)	39 (28DAT)	67 (28DAT)
Greenville, Mississippi MRID 50958206	Vegetative Growth (July 30, 2019)	14-DAT Height	0.00028	0.0000872	0.00173	35	26	52
		28-DAT Height	<0.00028	0.0000729	0.00107	24	10	40
		Yield	<0.00028	1.1E-05	0.001	35 (14DAT)	9 (14DAT)	49 (14DAT)
						24 (28DAT)	<5 (28DAT)	43 (28DAT)
	Reproductive (August 9, 2019)	14-DAT Height	0.00025	0.000487	0.0022	19	30	50
		28-DAT Height	<0.00025	0.000192	0.00113	33	15	38
		Yield	0.00025	0.00015	0.002	19 (14DAT)	15 (14DAT)	45 (14DAT)
						33 (28DAT)	11 (28DAT)	42 (28DAT)
Stewardson, Illinois MRID 51017505	Vegetative Growth (August 5, 2019)	14-DAT Height	0.00065	0.000375	0.00189	23	18	33
		28-DAT Height	<0.00030	0.000194	0.00138	10	10	35
		Yield	<0.00030	0.00006	0.001	15 (14DAT)	2 (14DAT)	27 (14DAT)
						10 (28DAT)	<5 (28DAT)	33 (28DAT)
	Reproductive (August 15, 2019)	14-DAT Height	0.0011	0.00156	0.00612	30	30	45
		28-DAT Height	0.00055	0.000613	0.00412	23	22	50
		Yield	0.00055	0.00025	0.002	23 (14DAT)	10 (14DAT)	32 (14DAT)
						23 (28DAT)	9 (28DAT)	38 (28DAT)
Fisk, Missouri MRID 51017506	Vegetative Growth (August 8, 2019)	14-DAT Height	0.00081	0.00034	0.0027	38	30	47
		28-DAT Height	0.00035	0.0000996	0.002	20	13	34
		Yield	0.0087	NC	NC	55 (14DAT)	NC (14DAT)	NC (14DAT)
						45 (28DAT)	NC (28DAT)	NC (28DAT)
	Reproductive (August 27, 2019)	14-DAT Height	0.0016	0.0016	0.0084	23	25	42
		28-DAT Height	0.00064	0.000565	0.00823	30	22	57
		Yield	0.0032	0.00159	0.006	71 (14DAT)	25 (14DAT)	38 (14DAT)

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Location MRID	Growth Stage and Date	Endpoint	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}	% VSI at NOAEC	%VSI at EC_{05}/IC_{05}	%VSI at EC_{25}/IC_{25}
						36 (28DAT)	35 (28DAT)	52 (28DAT)
Perry, Missouri MRID 50958205	Vegetative Growth (July 22, 2019)	14-DAT Height	0.00056	0.000849	0.00278	38	30	47
		28-DAT Height	0.0003	0.000428	0.00193	20	13	34
		Yield	0.0022	NC	NC	48 (14DAT)	NC (14DAT)	NC (14DAT)
						46 (28DAT)	NC (28DAT)	NC (28DAT)
	Reproductive (August 7, 2019)	14-DAT Height	0.00056	0.000479	0.00211	30	33	45
		28-DAT Height	<0.00028	0.000214	0.00136	20	18	35
		Yield	0.0045	NC	NC	35 (14DAT)	NC (14DAT)	NC (14DAT)
						44 (28DAT)	NC (28DAT)	NC (28DAT)

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3.1.2. Comparing VSI to reductions in height and yield

Using logistic regressions of VSI vs concentration, EPA estimated the %VSI at each height and yield endpoint for all of the studies that reported an effect on yield. **Figure C.5** provides a direct comparison of the %height reduction and the %VSI at each of the LOAECs determined in the studies. The resulting %VSI to %Height relationship suggests a 2:1 relationship across much of the %height effect distribution, and because each of these are, by definition of the LOAEC, statistically different from the paired control in each study, there is additional confidence that the relationship is not an artifact of study variability. EPA also plotted the ICx regression for plant height and the associated %VSI at those concentrations. These illustrate that regression based estimates are predicting relationships that are along the same linear trend seen in the LOAEC data. At the IC_{05}s the ratio of VSI is approximately 2:1 to 3:1. The relationship is conserved across the different endpoints (**Table C.14**) and growth stages of exposure. EPA used these relationships of VSI to 5% height and VSI to 5% yield in the establishment of a protective %VSI threshold (**Appendix D**), which were used in the process for establishing distances to effect (**Appendix E**) and evaluating the protectiveness of the labeled in-field application setbacks (**Appendix F**).
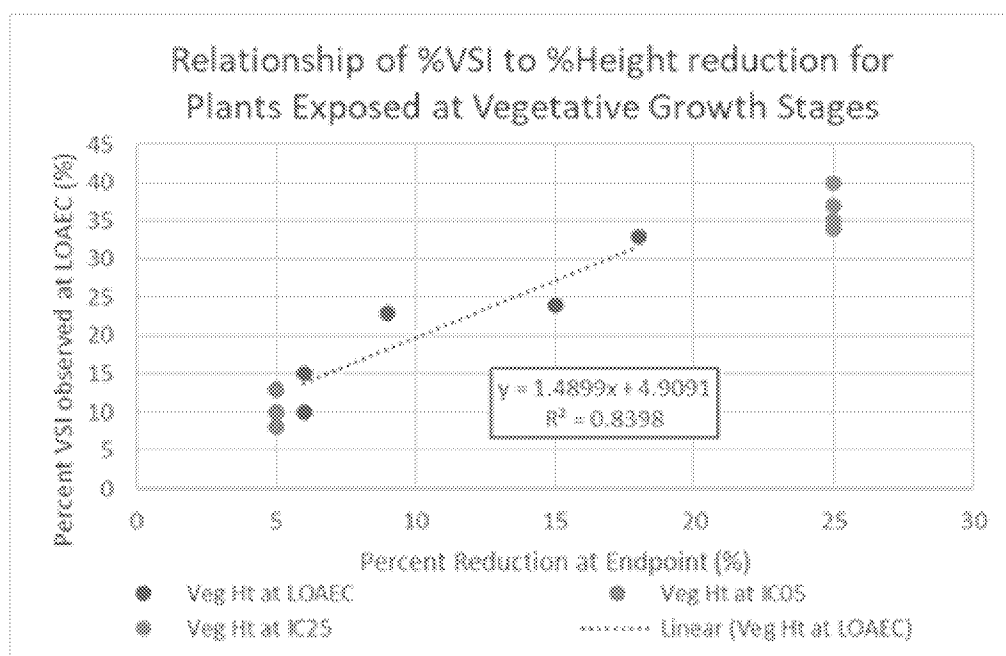
Figure C.5. Example relationship of percent VSI and percent reduction in plant height at the LOAECs, IC_{05}s and IC_{25}s for the vegetative exposure experiments. A linear regression model was fit to the LOAECs to illustrate the trend in the data and to lend credence to the estimated VSI at the IC_{05} and IC_{25}.

Table C.14. Ratio of VSI to Height and Yield Endpoints.

Exposure and Endpoint	VSI:LOAEC	VSI:IC$_{25}$	VSI:IC$_{05}$
Plant Height – Vegetative Exposure	Average = 2.0 Range = 1.6-2.6	Average = 1.4 Range = 1.4-1.6	Average = 2.2 Range = 1.6-2.6
Plant Height - Reproductive Exposure	Average = 3.4 Range = 1.4-6.0	Average = 1.9 Range = 1.5-2.3	Average = 3.4 Range = 1.4-4.4
Plant Yield Vegetative Exposure	Average = 1.4 Range = 0.8-2.2	Average = 2.0 Range = 1.3-2.8	Average = 3.2 Range = 1.0-7.0
Plant Yield Reproductive Exposure	Average = 2.9 Range = 1.7-5.6	Average = 2.0 Range = 1.5-2.7	Average = 3.9 Range = 1.8-7.8

3.2. Individual Study Summaries:

3.2.1. Perry, Missouri – MRID 50958205

This study reported the effect of Clarity® formulation (a.i. Dicamba DGA salt) + Roundup PowerMAX® formulation (a.i. Glyphosate potassium salt) + Intact™ (drift reduction agent) on the vegetative vigor and yield of dicamba non-tolerant/glyphosate-tolerant soybean, (*Glycine max*; var. Beck's 4268FP). Nominal concentrations ranged from 0.00030 to 0.0048 lb ae dicamba/A and 0.00068 to 0.011 lb ae glyphosate/A in the spray tank solution. The test concentrations of dicamba and glyphosate were analytically confirmed at all treatment levels.

The study was conducted in a field located in northeast Missouri (silt loam, pH 5.6, organic matter 2.5%). The study targeted application during two developmental growth stages, early vegetative growth stage (V3) and flowering reproductive stage (R1). The treatment field was divided into two equal fields with 24 replicate plots for each test; non-dicamba tolerant soybeans were planted on July 1, 2019. The test solutions were applied to the respective field on July 22, 2019 and August 7, 2019 for the vegetative growth test and the reproductive test, respectively. On 14 and 29 days after treatment (DAT) for the vegetative growth stage test and 14 and 28 DAT for the reproductive test, soybean plants were measured for height and assessed for visual morphology. On November 6, 2019 (107 DAT for the vegetative growth test and 92 DAT for the reproductive test), soybean plants were harvested for determination of yield for both studies.

Comparisons across the IC$_{25}$ estimates suggests similar response levels for plant height across vegetative and reproductive phase exposures and observation periods (14DAT or 28DAT). The most sensitive endpoint was based on 28DAT height in the reproductive stage, with NOAEC and IC$_{25}$ values of <0.00028 and 0.00136 lb ae/A dicamba, respectively. Yield was not impacted in this study.

Reported VSI included leaf cupping, epinasty of both stems and petioles, and some stunting and were readily apparent and significant (>12%) at all application rates in the vegetative growth and reproductive stage study. VSI was evaluated using logistic regression in Excel fit to observed VSI for each test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.6 and C.7** were used to estimate the %VSI for regression based IC$_x$ values for plant height and yield. **Tables C.15 and C.16** provide the observed NOAECs, estimated (IC$_x$) and average %VSI for each height and yield endpoint for 14DAT and 28DAT.

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Results Synopsis

A summary of the endpoints for height and yield are provided for dicamba (**Table C.15**). Also provided in **Figures C.6 & C.7** are the response relationships between height, VSI, yield, test concentration and evaluation time step. The average %VSI for each height and yield endpoint is provided in **Table C.16**. This study is scientifically sound and is classified as supplemental.

Table C.15. MRID 50958205: Summary of most sensitive parameters (lb ae/A Dicamba).

Species	Stage	Endpoint	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	14-DAT Height	0.00056	0.000849	0.00278
		28-DAT Height	0.0003	0.000428	0.00193
		Yield	0.0022	NC	>0.0045
	Reproductive	14-DAT Height	0.00056	0.000479	0.00211
		28-DAT Height[1]	<0.00028	0.000214	0.00136
		Yield	0.0048	NC	>0.0048

NC- Not calculable.
[1] Significant effects at all application rates, indicating lowest test concentration did not bracket effects at the lowest concentration range, and range of application rates was inadequate to accurately determine sensitivity to the test material.

Table C.16. MRID 50958205: Summary of Estimated Average % VSI at Endpoint Concentrations provided in Table C.15. (%)

Species	Stage	Endpoint*	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	VSI 14-DAT Height	30	33	45
		VSI 28-DAT Height	20	18	35
		VSI Yield [a]	43 (14DAT) 34 (28DAT)	NC	NC
	Reproductive	VSI 14-DAT Height	25	24	33
		VSI 28-DAT Height	21	37	42
		VSI Yield [a]	38 (14DAT) 44 (28DAT)	NC	NC

*Endpoints in **Table C.15** were used to a) provide the observed VSI at the NOAEC, and b) estimate the %VSI at height and yield IC_x endpoints using logistic regression equations fit to study reported VSI on 14-DAT and 28-DAT.
[a] VSI was not assessed at the time of harvest, therefore %VSI for Yield is presented as the observed or predicted %VSI at 14DAT and 28DAT for the Yield endpoints in **Table C.15**.
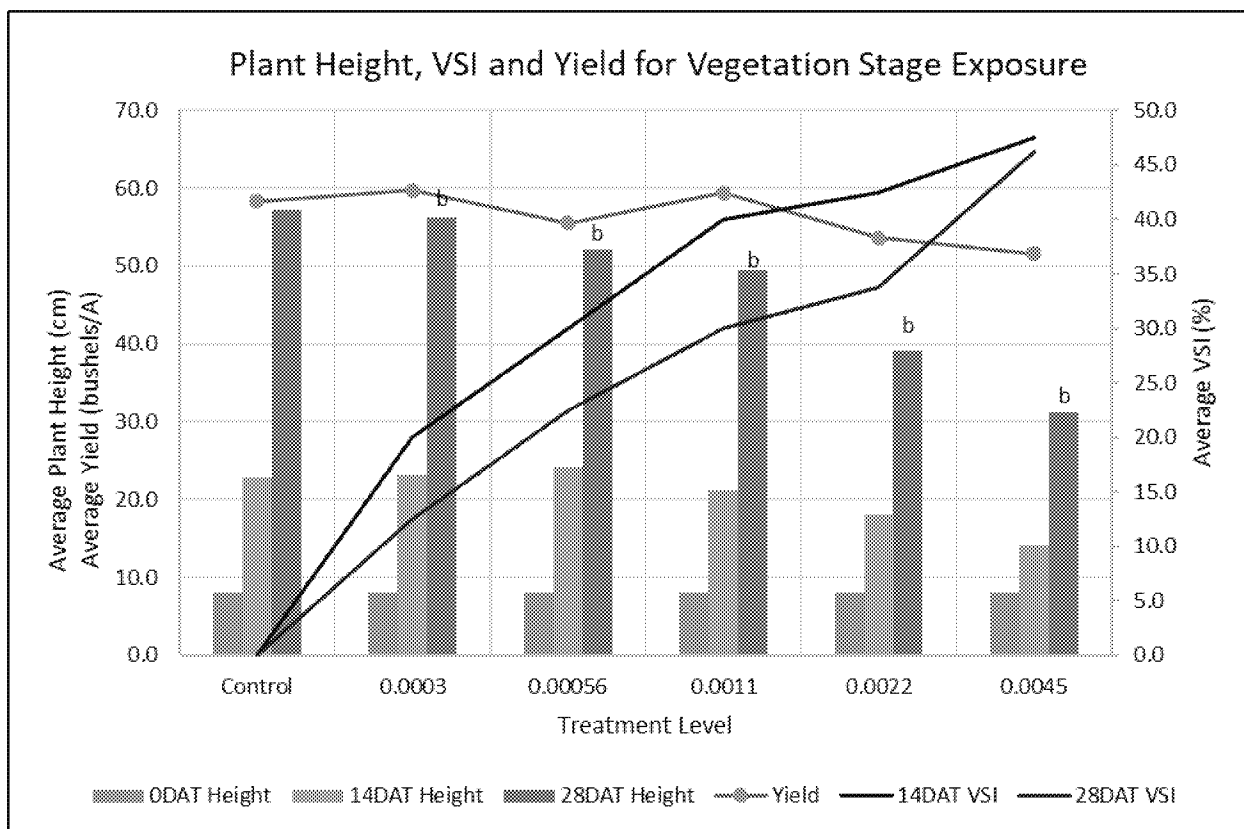
Figure C.6: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during vegetative growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.
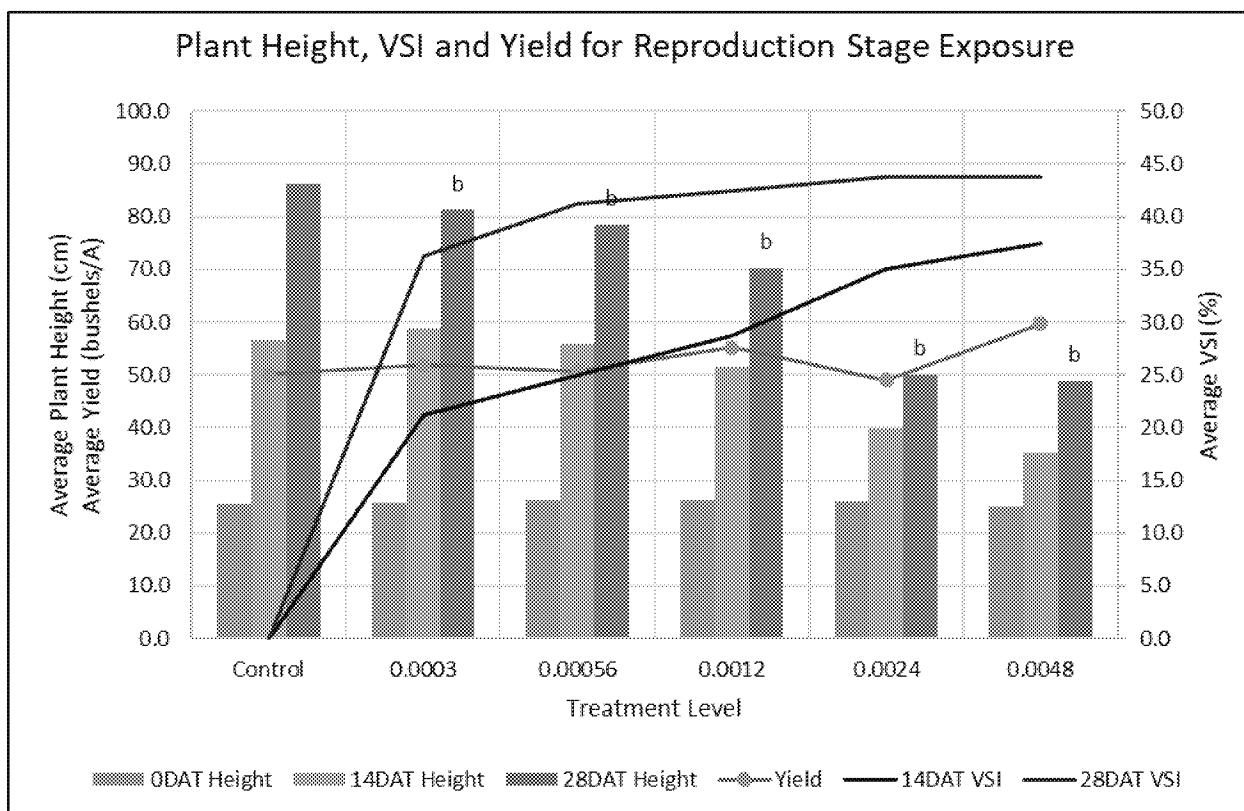
Figure C.7: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during reproductive growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.

Logistic regression was used to fit a regression to observed VSI against test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.8 and C.9** were used to estimate the %VSI for regression based ICx values for plant height and yield. See **Table C.16** for the results of these estimation procedures.

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VSI Vegetative Exposure

$$y = 9.8888\ln(x) + 103.11$$
$$R^2 = 0.9335$$

$$y = 11.599\ln(x) + 107.72$$
$$R^2 = 0.9748$$

Legend: ● 14DAT VSI ● 28DAT VSI ·········· Log. (14DAT VSI) ·········· Log. (28DAT VSI)
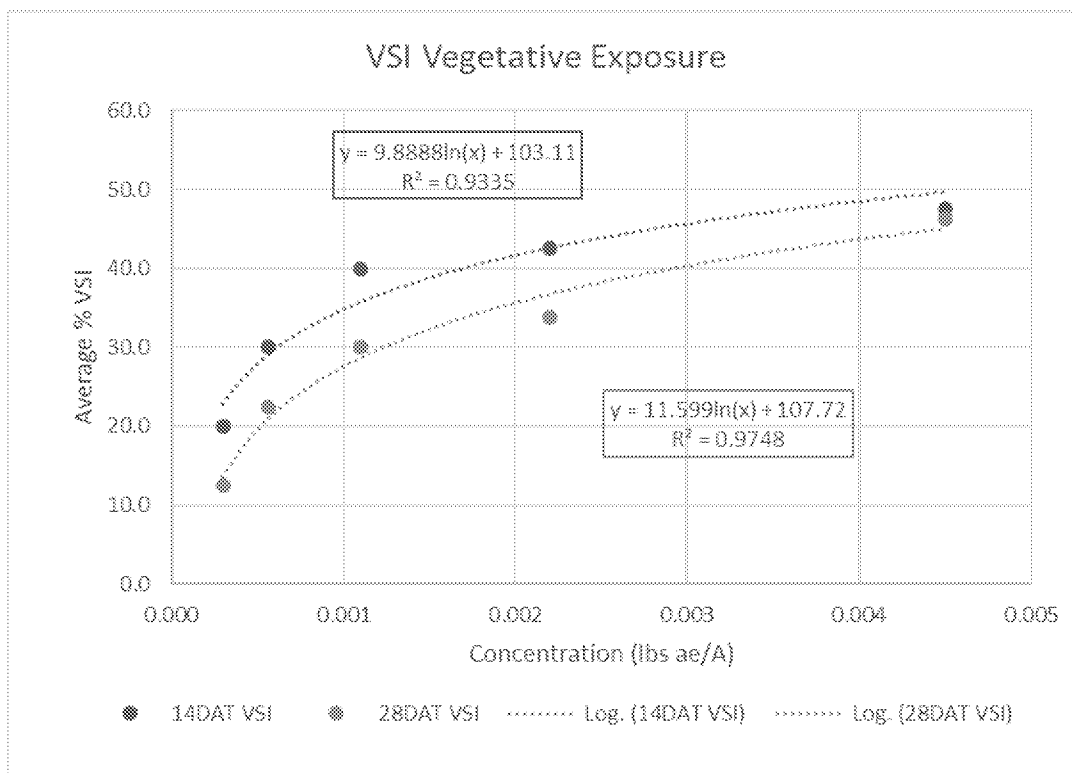
Figure C.8. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a vegetative growth stage exposure.

VSI Reproductive Exposure

$$y = 6.0704\ln(x) + 70.41$$
$$R^2 = 0.9868$$

$$y = 2.477\ln(x) + 58.193$$
$$R^2 = 0.7765$$

Legend: ● 14DAT VSI ● 28DAT VSI ·········· Log. (14DAT VSI) ·········· Log. (28DAT VSI)
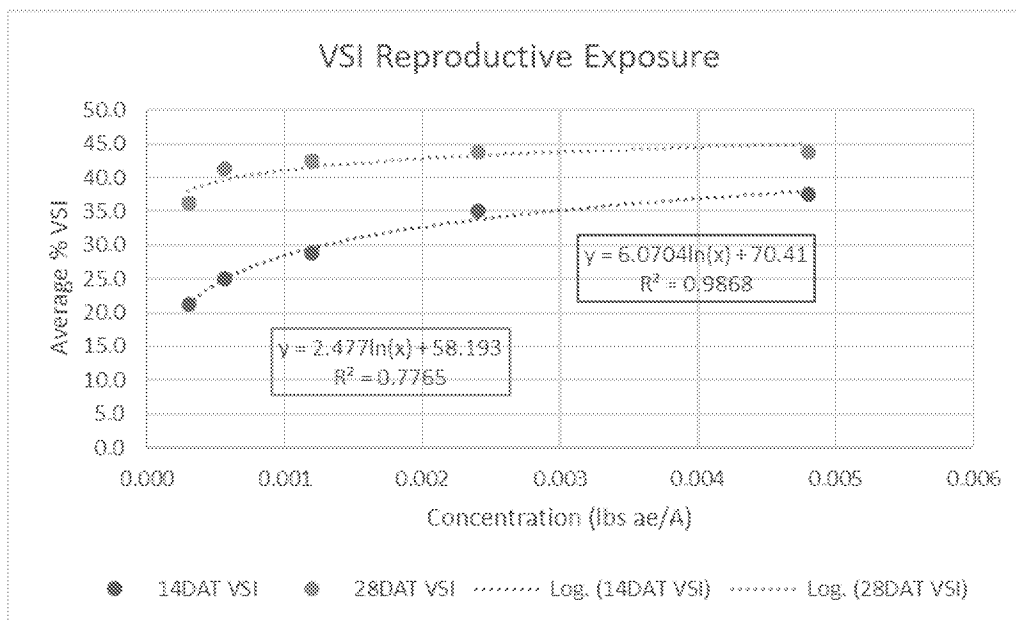
Figure C.9. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a reproductive growth stage exposure.

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ED_005172C_00001997-00161

3.2.2. Greenville, Mississippi - MRID 50958206

This study reported the effect of Clarity® formulation (a.i. Dicamba DGA salt) + Roundup PowerMAX® formulation (a.i. Glyphosate potassium salt) + Intact™ (drift reduction agent) on the vegetative vigor and yield of dicamba non-tolerant/glyphosate-tolerant soybean, (*Glycine max*; var. AgVenture 45W7R-DU23). Nominal concentrations ranged from 0.00030 to 0.0048 lb ae dicamba/A and 0.00068 to 0.011 lb ae glyphosate/A in the spray tank solution. The test concentrations were analytically confirmed at all treatment levels.

The study was conducted in a field located in Greenville, Mississippi (silt loam, pH 5.7, organic matter 0.98%).

The study targeted application during two developmental growth stages, early vegetative growth stage (V3) and flowering reproductive stage (R1). The treatment field was divided into two equal fields with 24 replicate plots for each test; non-dicamba tolerant soybeans were planted on July 5, 2019. The test solutions were applied to the respective field on July 30, 2019 and August 9, 2019 for the vegetative growth test and the reproductive test, respectively. On 14 and 28 days after treatment (DAT) for the vegetative growth and reproductive stage test, soybean plants were measured for height and assessed for visual morphology. On November 6, 2019 (99 DAT for the vegetative growth test and 90 DAT for the reproductive test), soybean plants were harvested for determination of yield for both studies.

Comparisons across the IC_{25} estimates suggests similar response levels for plant height across vegetative and reproductive phase exposures and observation periods (14DAT or 28DAT). The most sensitive endpoint was based on 28DAT height in the vegetative stage, with NOAEC and IC_{25} values of <0.00028 and 0.00107 lb ae/A dicamba, respectively.

Reported VSI included leaf cupping, epinasty of both stems and petioles, and some stunting and were readily apparent and significant (>18%) at all application rates the vegetative growth and reproductive stage study. Control plots were observed to have been exposed to dicamba as well. They all showed 5% VSI by day 14 observations in both reproductive and vegetative stage studies. VSI was evaluated using logistic regression in Excel fit to observed VSI for each test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in Figures 3 and 4 were used to estimate the %VSI for regression based IC_x values for plant height and yield. Tables C16 and C17 provide the observed (NOAECs) and estimated (IC_x) average %VSI for each height and yield endpoint for 14DAT and 28DAT.

Results Synopsis

A summary of the endpoints for height and yield are provided for dicamba (**Table C.17**). Also provided in **Figures C.10** & **C.11** are the response relationships between height, VSI, yield, test concentration and evaluation time step. The average %VSI for each height and yield endpoint is provided in **Table C.17**. This study is scientifically sound and is classified as supplemental.

Table C.17. MRID 50958206: Summary of most sensitive parameters (lb ae/A Dicamba).

Species	Stage	Endpoint	NOAEC	EC₀₅/IC₀₅	EC₂₅/IC₂₅
Soybean	Vegetative Growth	14-DAT Height	0.00028	0.0000872	0.00173
		28-DAT Height	<0.00028	0.0000729	0.00107
		Yield	<0.00028	0.0000111	0.00129
	Reproductive	14-DAT Height	0.00025	0.000487	0.0022
		28-DAT Height	<0.00025	0.000192	0.00113
		Yield	0.00025	0.00015	0.00156

[1] Significant effects at all application rates, indicating lowest test concentration did not bracket effects at the lowest concentration range, and range of application rates was inadequate to accurately determine sensitivity to the test material.

Table C.18. MRID 50958206: Summary of Estimated Average % VSI at Endpoint Concentrations provided in Table C.17. (%)

Species	Stage	Endpoint	NOAEC	EC₀₅/IC₀₅	EC₂₅/IC₂₅
Soybean	Vegetative Growth	14-DAT Height	35	26	52
		28-DAT Height	24	10	40
		Yield	35 (14DAT) 24 (28DAT)	9 (14DAT) <5 (28DAT)	49 (14DAT) 43 (28DAT)
	Reproductive	14-DAT Height	19	30	50
		28-DAT Height	33	15	38
		Yield	19 (14DAT) 33 (28DAT)	15 (14DAT) 11 (28DAT)	45 (14DAT) 42 (28DAT)

[*] Endpoints in **Table C.17** were used to a) provide the observed VSI at the NOAEC, and b) estimate the %VSI at height and yield IC_x endpoints using logistic regression equations fit to study reported VSI on 14-DAT and 28-DAT.
[a] VSI was not assessed at the time of harvest, therefore %VSI for Yield is presented as the observed or predicted %VSI at 14DAT and 28DAT for the Yield endpoints in **Table C.17**.
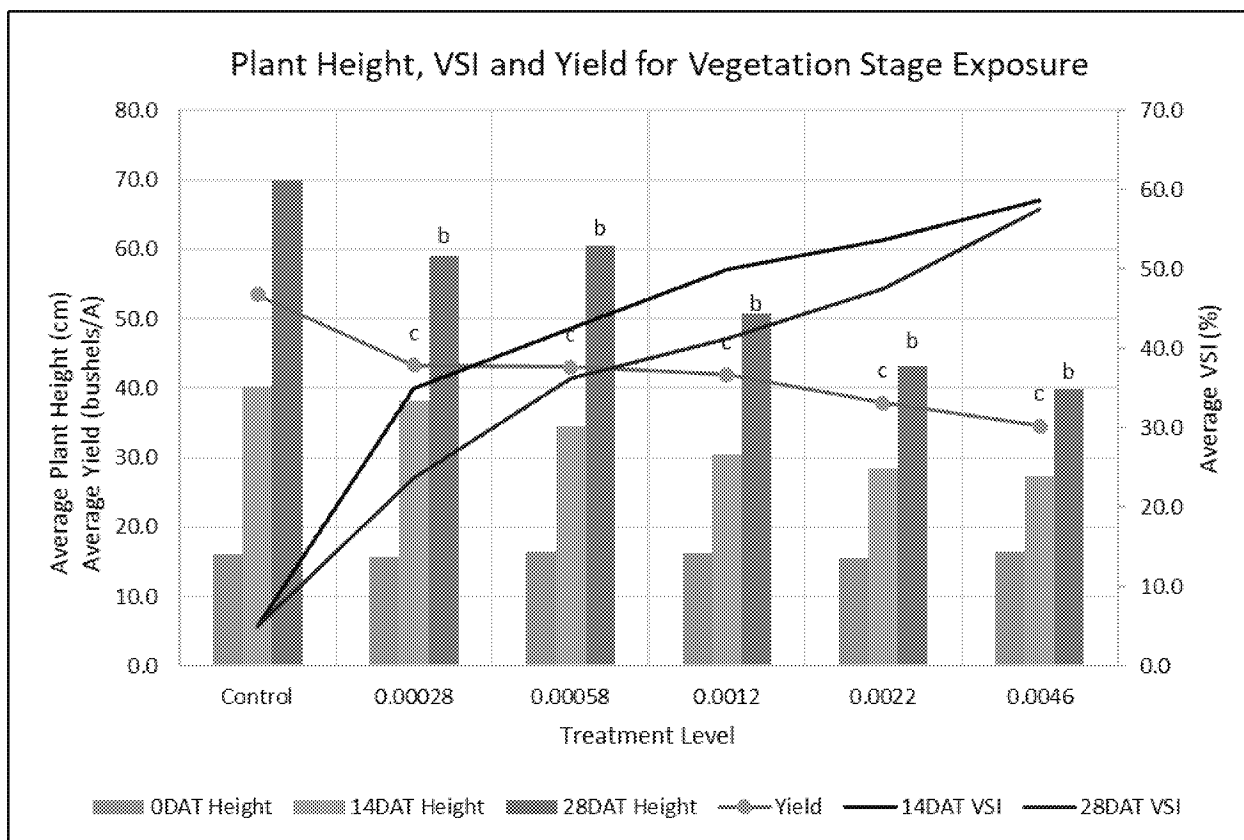
Figure C.10: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during vegetative growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.
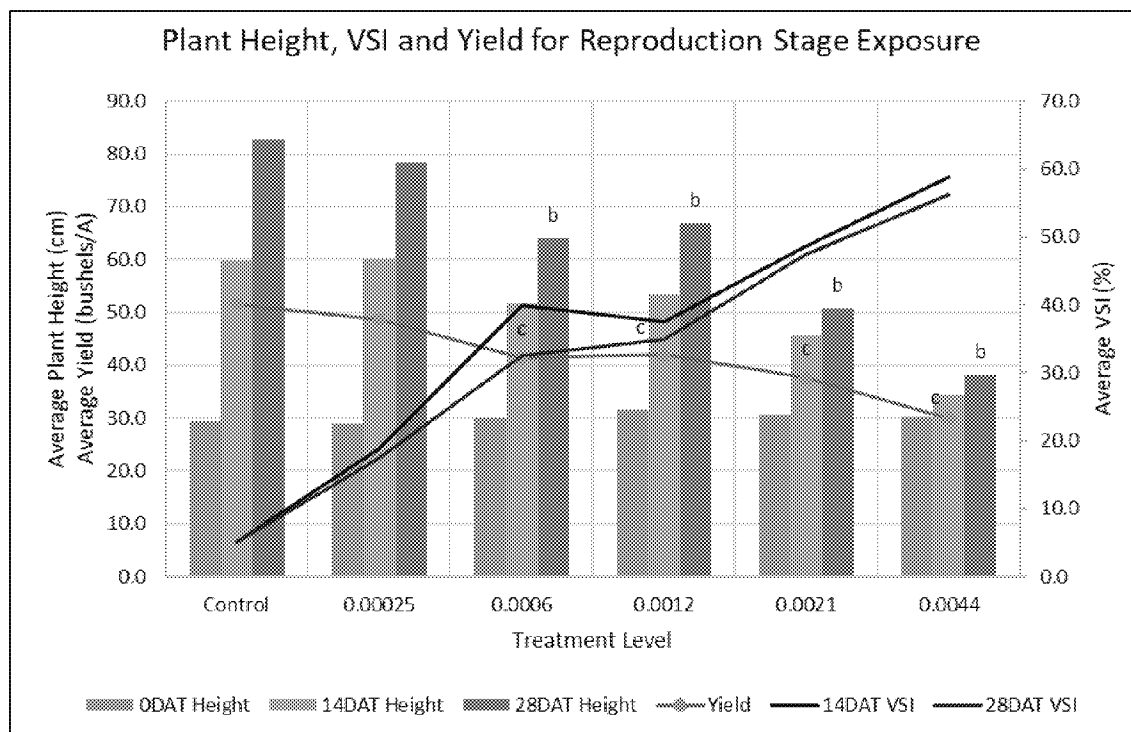
Figure C.11: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during reproductive growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.

Logistic regression was used to fit a regression to observed VSI against test dose No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.12 and C.13** were used to estimate the %VSI for regression based ICx values for plant height and yield. See **Table C.18** for the results of these estimation procedures.
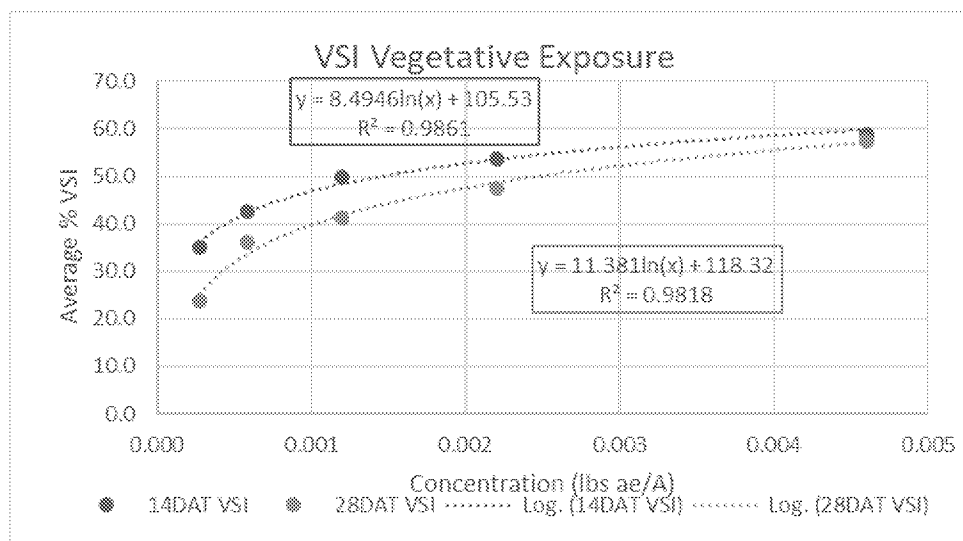
Figure C.12. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a vegetative growth stage exposure.

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ED_005172C_00001997-00165

VSI Reproductive Exposure

$$y = 12.81\ln(x) + 127.93$$
$$R^2 = 0.9123$$

$$y = 13.218\ln(x) + 127.71$$
$$R^2 = 0.972$$
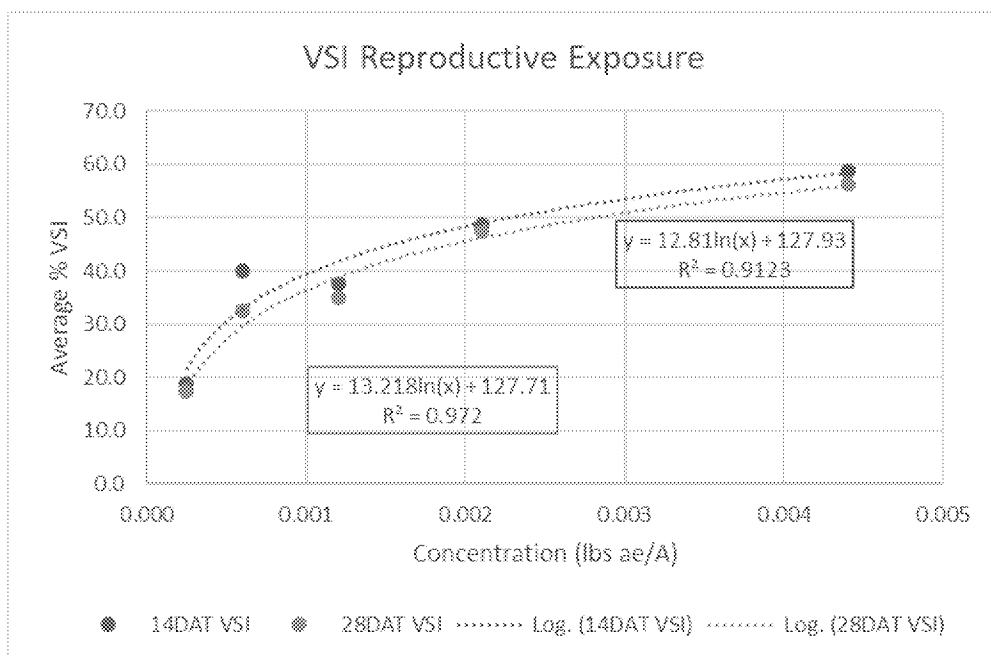
Figure C.13. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a reproductive growth stage exposure.

3.2.3. Greenville, Mississippi - MRID 51017504

This study reported the effect of Clarity® formulation (a.i. Dicamba DGA salt) + Roundup PowerMAX® formulation (a.i. Glyphosate potassium salt) + Intact™ (drift reduction agent) on the vegetative vigor and yield of dicamba non-tolerant/glyphosate-tolerant soybean, (*Glycine max*; var. NK S-45-W9). Nominal concentrations ranged from 0.00030 to 0.0048 lb ae dicamba/A and 0.000675 to 0.0108 lb ae glyphosate/A in the spray tank solution. The test concentrations of dicamba and glyphosate were analytically confirmed at all treatment levels.

The study was conducted in a field located in Greenville, Mississippi (soils: sandy loam, pH 7, organic matter 1%).

The study targeted application during two developmental growth stages, early vegetative growth stage (V4) and flowering reproductive stage (R2). The treatment field was divided into two equal fields with 24 replicate plots for each test; non-dicamba tolerant soybeans were planted on May 31, 2019. The test solutions were applied to the respective field on June 27, 2019 and July 11, 2019 for the vegetative growth test and the reproductive test, respectively. On 14 and 28 days after treatment (DAT), soybean plants were measured for height and assessed for visual morphology. Soybean plants were later harvested for determination of yield for both studies.

When compared to the negative control plants, significant inhibitions in soybean plant height were found for both the vegetative growth and reproductive stages. For both stages, significant inhibitions in soybean height were found at 0.00031 lb ae dicamba/A and higher.

When compared to the negative control plants, significant inhibitions in soybean yield were found for both the vegetative growth and reproductive stages. For the vegetative growth stage, significant inhibitions in soybean yield were found at 0.00063 lb ae dicamba/A and higher (NOAEC = 0.00031 lb ae dicamba/A). For the reproductive stage, significant inhibitions in soybean yield were found at 0.0013 lb ae dicamba/A and higher (NOAEC = 0.00059 lbs a.e. dicamba/A).

Comparisons across the IC_{25} estimates suggests similar response levels for plant height across vegetative and reproductive phase exposures and observation periods (14DAT or 28DAT). The most sensitive endpoint was based on 28DAT height in the reproductive stage, with NOAEC and IC_{25} values of <0.00032 and 0.00163 lb ae/A dicamba, respectively. Significant effects were observed at all application rates for all tests.

Reported VSI included leaf cupping, epinasty of both stems and petioles, and some stunting and were readily apparent and significant (>20%) at all application rates the vegetative growth and reproductive stage study. In the reproductive stage study, in addition to vegetative injury, some pods were curled and there was compression of the main stem internodes. VSI was evaluated using logistic regression in Excel fit to observed VSI for each test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in Figures 3 and 4 were used to estimate the %VSI for regression based IC_x values for plant height and yield. Table C18 provides the observed (NOAECs) and estimated (IC_x) average %VSI for each height and yield endpoint for 14DAT and 28DAT.

Results Synopsis

A summary of the endpoints for height and yield are provided for dicamba (**Table C.19**). Also provided in **Figures C.14 & C.15** are the response relationships between height, VSI, yield, test concentration and evaluation time step. The average %VSI for each height and yield endpoint is provided in **Table C.20**. This study is scientifically sound and is classified as supplemental.

Table C.19. MRID 51017504: Summary of most sensitive parameters (lb ae/A Dicamba).

Species	Stage	Endpoint	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	14-DAT Height[1]	<0.00031	0.000348	0.00170
		28-DAT Height[1]	<0.00031	0.000219	0.00207
		Yield	0.00031	0.000502	0.0263
	Reproductive	14-DAT Height	0.00059	0.000304	0.00236
		28-DAT Height[1]	<0.00032	0.000236	0.00163
		Yield	0.00059	0.00136	0.00677

[1] Significant effects at all application rates, indicating lowest test concentration did not bracket effects at the lowest concentration range, and range of application rates was inadequate to accurately determine sensitivity to the test material.

Table C.20. MRID 51017504: Summary of Estimated Average % VSI at Endpoint Concentrations provided in Table C.19.

Species	Stage	Endpoint[*]	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	VSI 14-DAT Height	14	19	34
		VSI 28-DAT Height	15	8	37
		VSI Yield [a]	14 (14DAT) 15 (28DAT)	21.1 (14DAT) 18.6 (28DAT)	60.0 (14DAT) 70.5 (28DAT)
	Reproductive	VSI 14-DAT Height	27	19	44
		VSI 28-DAT Height	14	7	42
		VSI Yield [a]	28 (14DAT) 21 (28DAT)	37.0 (14DAT) 38.5 (28DAT)	56.6 (14DAT) 66.9 (28DAT)

[*] Endpoints in **Table C.19** were used to a) provide the observed VSI at the NOAEC, and b) estimate the %VSI at height and yield IC_x endpoints using logistic regression equations fit to study reported VSI on 14-DAT and 28-DAT.
[a] VSI was not assessed at the time of harvest, therefore %VSI for Yield is presented as the observed or predicted %VSI at 14DAT and 28DAT for the Yield endpoints in **Table C.19**.
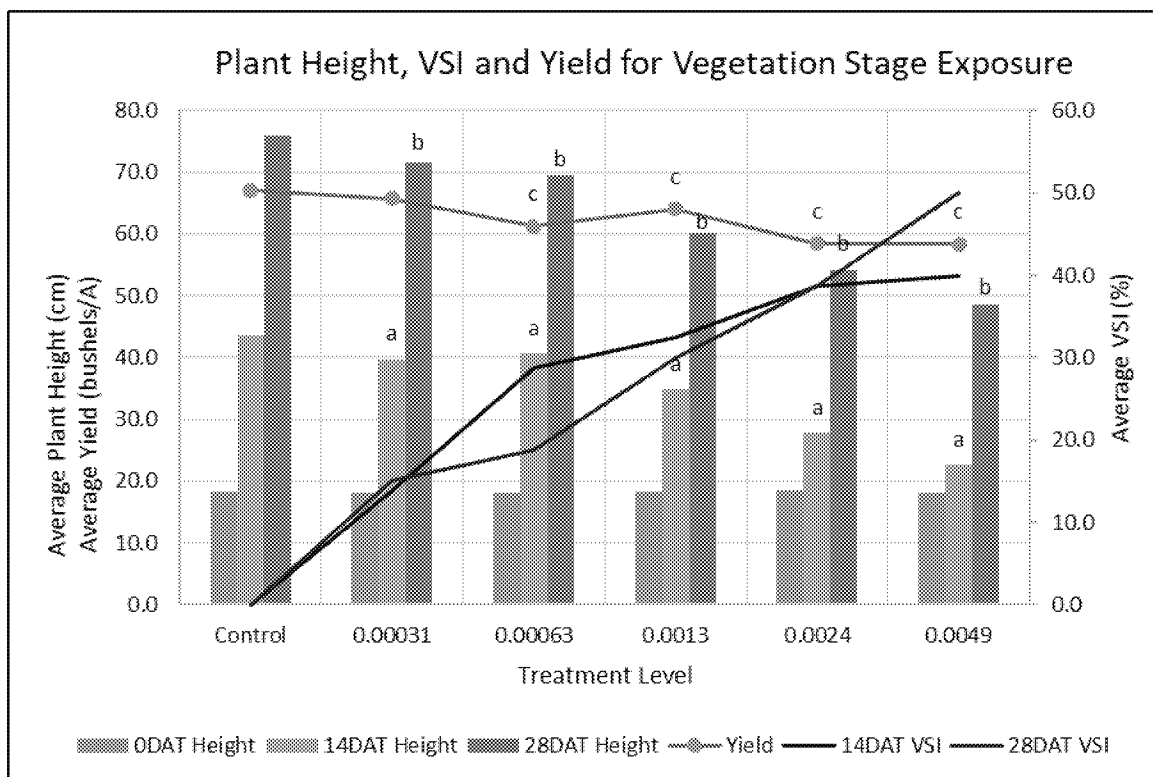
Figure C.14: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during vegetative growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.
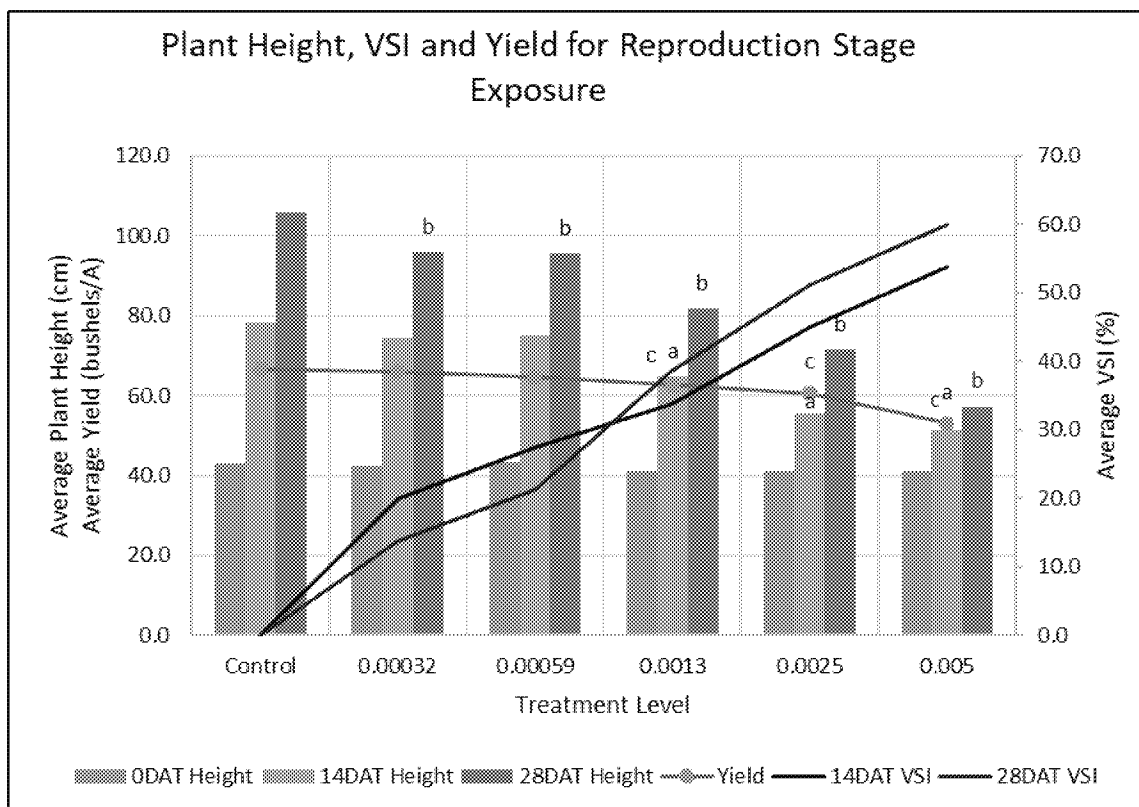
Figure C.15: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during reproductive growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.

Logistic regression was used to fit a regression to observed VSI against test dose No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.16 and C.17** were used to estimate the %VSI for regression based ICx values for plant height and yield. See **Table C.20** for the results of these estimation procedures.

VSI Vegetative Exposure

$y = 9.1352\ln(x) + 91.855$
$R^2 = 0.8814$

$y = 13.101\ln(x) + 118.13$
$R^2 = 0.977$
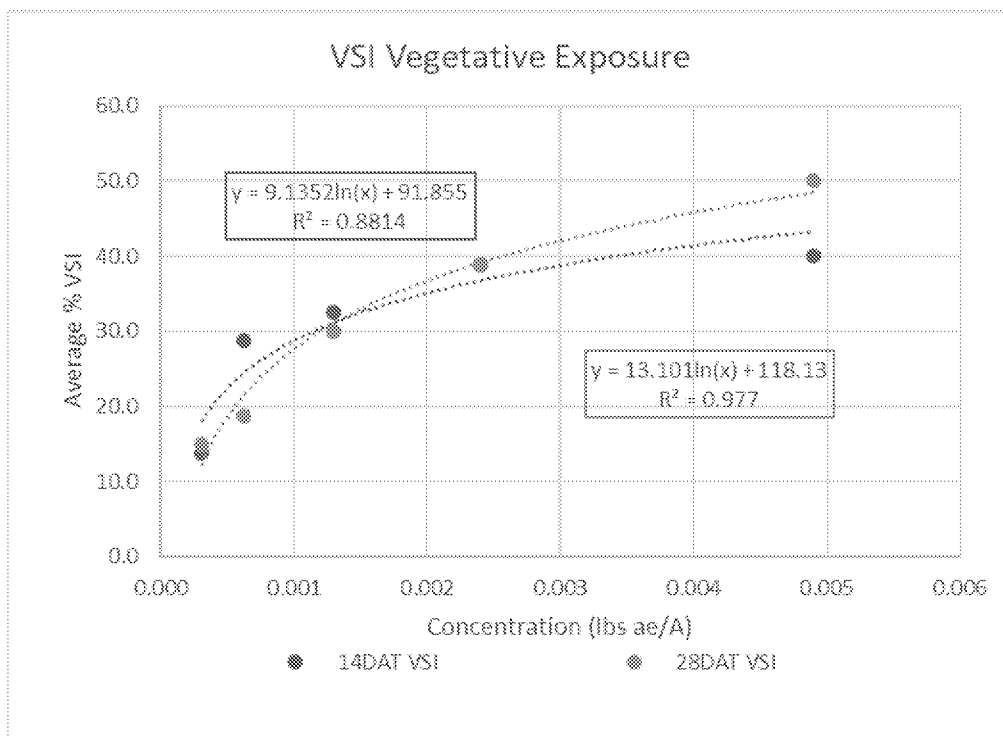
Figure C.16. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a vegetative growth stage exposure.

VSI Reproductive Exposure

$y = 17.689\ln(x) + 155.23$
$R^2 = 0.9907$

$y = 12.218\ln(x) + 117.66$
$R^2 = 0.9873$
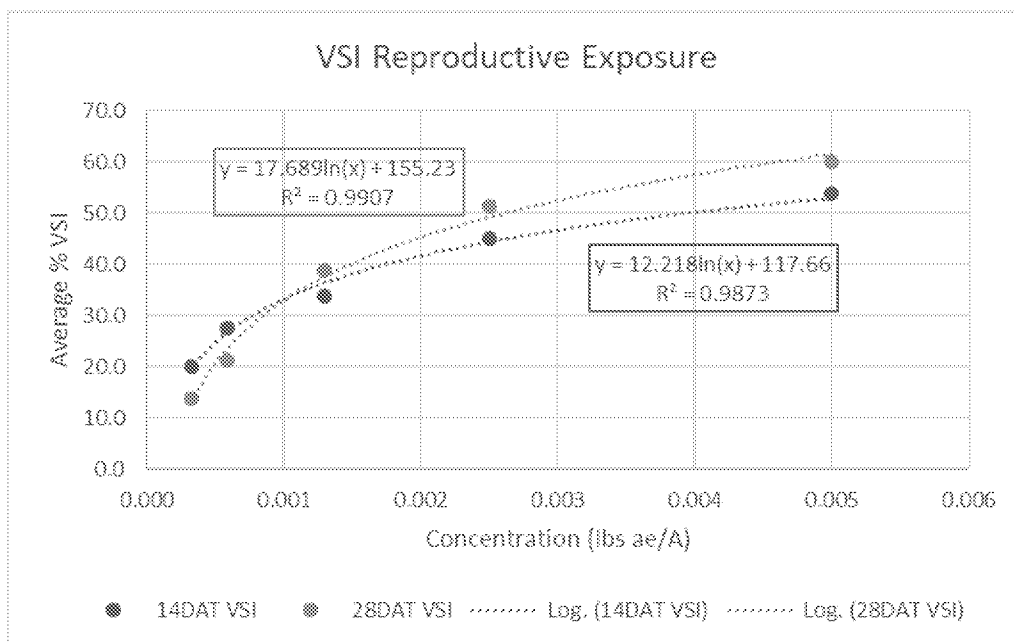
Figure C.17. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a reproductive growth stage exposure.

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ED_005172C_00001997-00171

3.2.4. Stewardson, Illinois - MRID 51017505

This study reported the effect of Clarity® formulation (a.i. Dicamba DGA salt) + Roundup PowerMAX® formulation (a.i. Glyphosate potassium salt) + Intact™ (drift reduction agent) on the vegetative vigor and yield of dicamba non-tolerant/glyphosate-tolerant soybean, (*Glycine max*; var. 35GA32). Nominal concentrations ranged from 0.00030 to 0.0048 lb ae dicamba/A and 0.00068 to 0.011 lb ae glyphosate/A in the spray tank solution. The test concentrations of dicamba and glyphosate were analytically confirmed at all treatment levels

The study was conducted in a field located in Illinois (silt loam, pH 6, organic matter 2%).

Two developmental growth stage application timings were assessed, early vegetative growth stage (V3) and flowering reproductive stage (R1). The treatment field was divided into two equal fields with 24 replicate plots for each test; non-dicamba tolerant soybeans were planted on July 11, 2019. The test solutions were applied to the respective field on August 5, 2019 and August 15, 2019 for the vegetative growth test and the reproductive test, respectively. On 28 days after treatment (DAT) for both experiments, soybean plants were measured for height and assessed for visual morphology. Soybean plants were harvested for determination of yield for both studies.

When compared to the negative control, significant inhibitions in soybean plant height were found for both the vegetative growth and reproductive stages. For the vegetative growth stage, significant inhibitions in soybean height were found at 0.0003 lb ae dicamba/A and higher (all test concentrations; NOAEC <0.0003 lbs a.e. dicamba/A). For the reproductive stage, significant inhibitions in soybean height were found at 0.0012 lb ae dicamba/A and higher (NOAEC = 0.00055 lbs a.e. dicamba/A)

When compared to the negative control, significant inhibitions in soybean yield were found for both the vegetative growth and reproductive stages. For the vegetative growth stage, significant inhibitions in soybean yield were found at 0.0003 lb ae dicamba/A and higher (all test concentrations). For the reproductive stage, significant inhibitions in soybean yield were found at 0.0012 lb ae dicamba/A and higher.

Based on the IC_{25s}, the most sensitive endpoint was yield in the vegetative growth stage, with NOAEC and IC_{25} values of <0.00030 and 0.00117 lb ae/A Dicamba, respectively.

Reported VSI included leaf cupping, epinasty of both stems and petioles, and some stunting and were readily apparent at all application rates in soybean plants in the vegetative growth study after 14 and 28 days. In the reproductive stage study, new growth leaves were cupped and some pods were curled in addition to compression of the main stem internodes. VSI was evaluated using logistic regression in Excel fit to observed VSI for each test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.20 and C.21** were used to estimate the %VSI for regression based ICx values for plant height and yield. **Table C.21** provides the observed (NOAECs) and estimated (ICx) average %VSI for each height and yield endpoint for 14DAT and 28DAT.

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Results Synopsis

A summary of the endpoints for height and yield are provided for dicamba (**Table C.21**). Also provided in **Figures C18 & C19** are the response relationships between height, VSI, yield, test concentration and evaluation time step. The average %VSI for each height and yield endpoint is provided in **Table C.22**. This study is scientifically sound and is classified as supplemental.

Table C.21. MRID 51017505: Summary of most sensitive parameters (lb ae/A Dicamba).

Species	Stage	Endpoint	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	14-DAT Height	0.00065	0.000375	0.00189
		28-DAT Height [1]	<0.00030	0.000194	0.00138
		Yield [1]	<0.00030	0.0000623	0.00117
	Reproductive	14-DAT Height	0.0011	0.00156	0.00612
		28-DAT Height	0.00055	0.000613	0.00412
		Yield	0.00055	0.000245	0.00186

[1] Significant effects at all application rates, indicating lowest test concentration did not bracket effects at the lowest concentration range, and range of application rates was inadequate to accurately determine sensitivity to the test material.

Table C.22. MRID 51017505: Summary of Estimated Average % VSI at Endpoint Concentrations provided in Table C.21 (%)

Species	Stage	Endpoint[*]	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	14-DAT Height	23	18	33
		28-DAT Height	10	10	35
		Yield [a]	15 (14DAT) 10 (28DAT)	2 (14DAT) <5 (28DAT)	29 (14DAT) 33 (28DAT)
	Reproductive	14-DAT Height	30	30	45
		28-DAT Height	23	22	50
		Yield [a]	23 (14DAT) 23 (28DAT)	10 (14DAT) 9 (28DAT)	32 (14DAT) 38 (28DAT)

[*] Endpoints in **Table C.21** were used to a) provide the observed VSI at the NOAEC, and b) estimate the %VSI at height and yield IC_x endpoints using logistic regression equations fit to study reported VSI on 14-DAT and 28-DAT. [a] VSI was not assessed at the time of harvest, therefore %VSI for Yield is presented as the observed or predicted %VSI at 14DAT and 28DAT for the Yield endpoints in **Table C.21**.
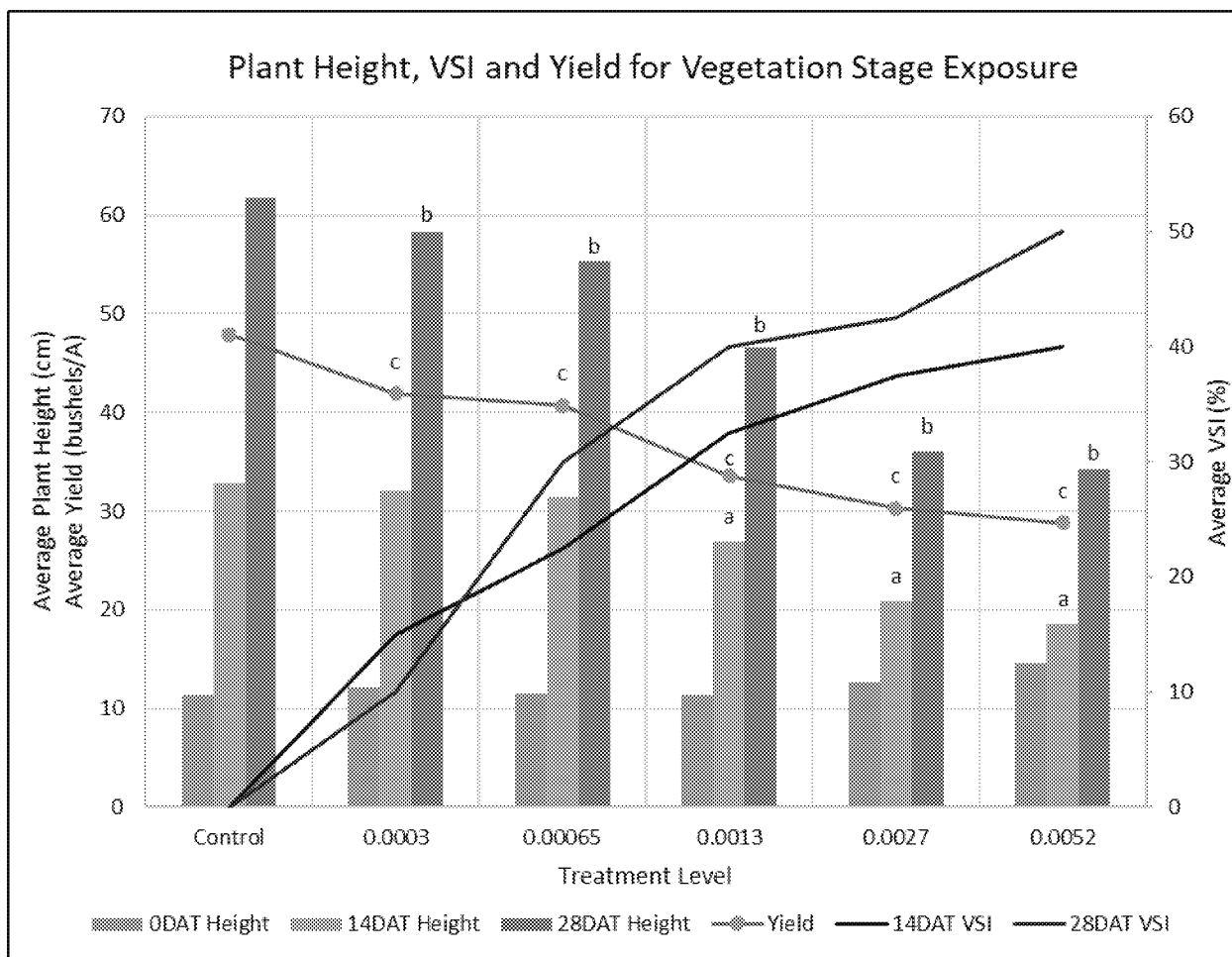
Figure C.18: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during vegetative growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.
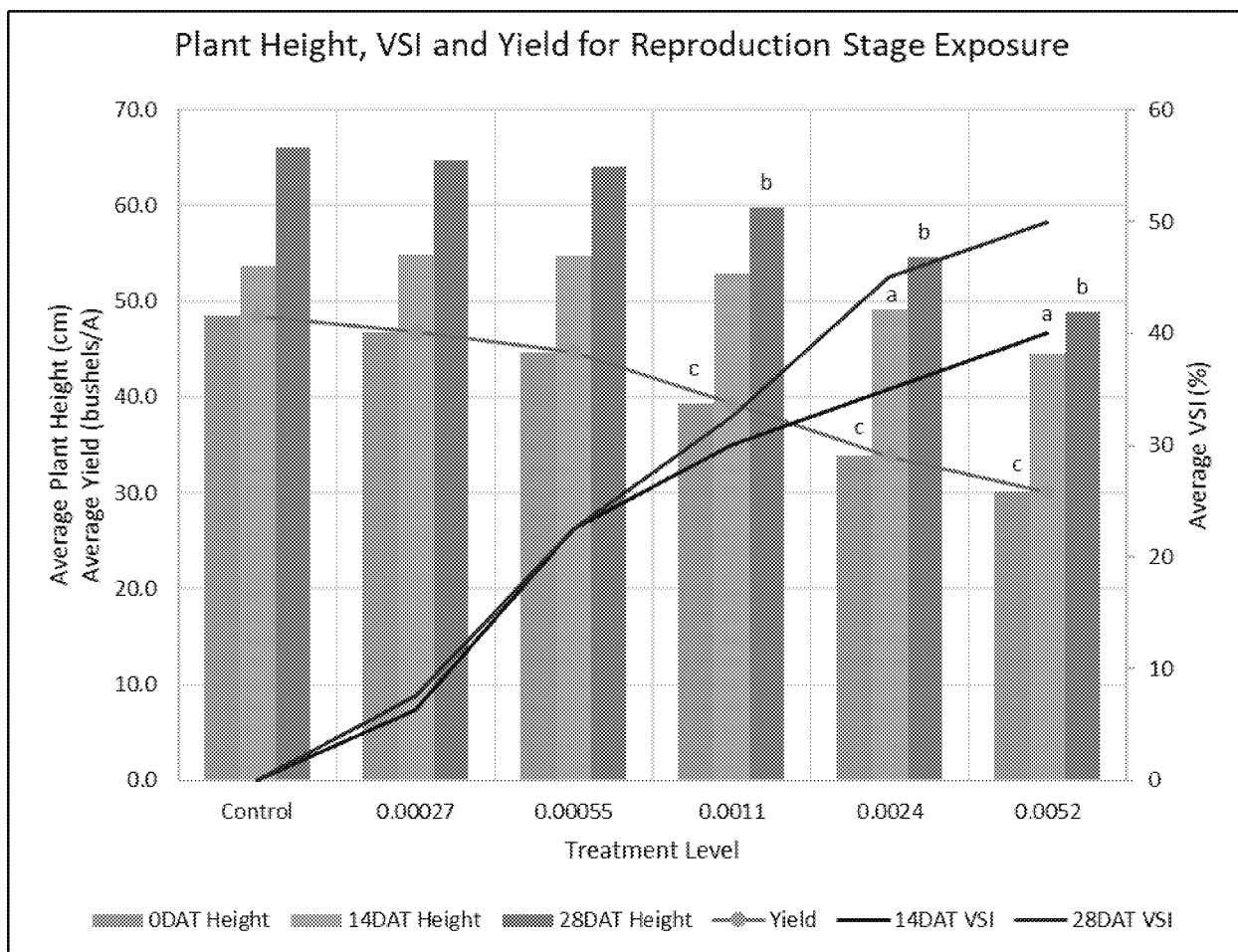
Figure C.19: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during reproductive growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.

Evaluation of Visual Signs of Injury (VSI)

Logistic regression was used to fit a regression to observed VSI against test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.20 and C.21** were used to estimate the %VSI for regression based ICx values for plant height and yield. See **Table C.22** for the results of these estimation procedures.

VSI Vegetative Exposure

$y = 13.051\ln(x) + 121.34$
$R^2 = 0.9071$

$y = 9.1457\ln(x) + 90.354$
$R^2 = 0.9614$

● 14DAT VSI ● 28DAT VSI ·········· Log. (14DAT VSI) ·········· Log. (28DAT VSI)
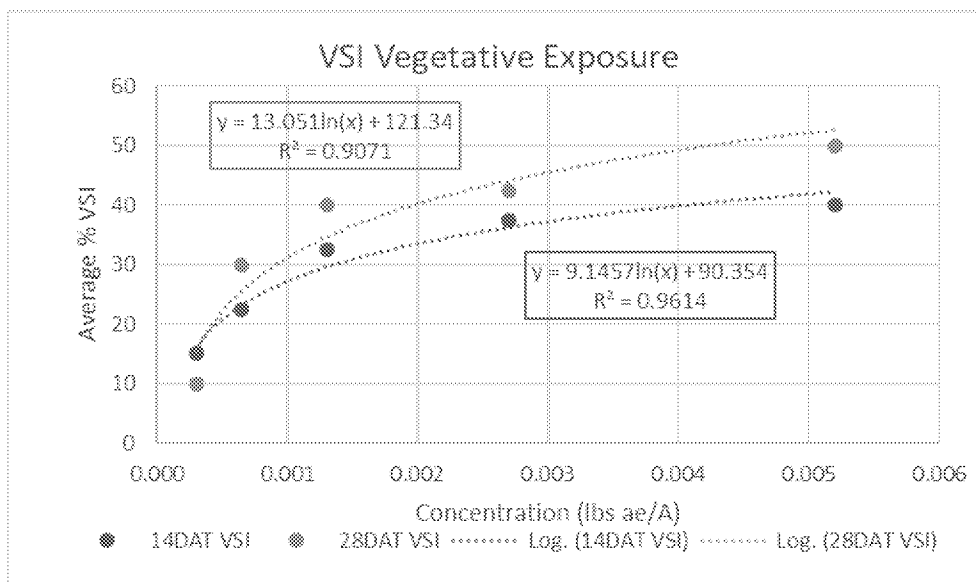
Figure C.20. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a vegetative growth stage exposure.

VSI Reproductive Exposure

$y = 14.499\ln(x) + 129.59$
$R^2 = 0.9713$

$y = 10.754\ln(x) + 99.505$
$R^2 = 0.9125$

● 14DAT VSI ● 28DAT VSI ·········· Log. (14DAT VSI) ·········· Log. (28DAT VSI)
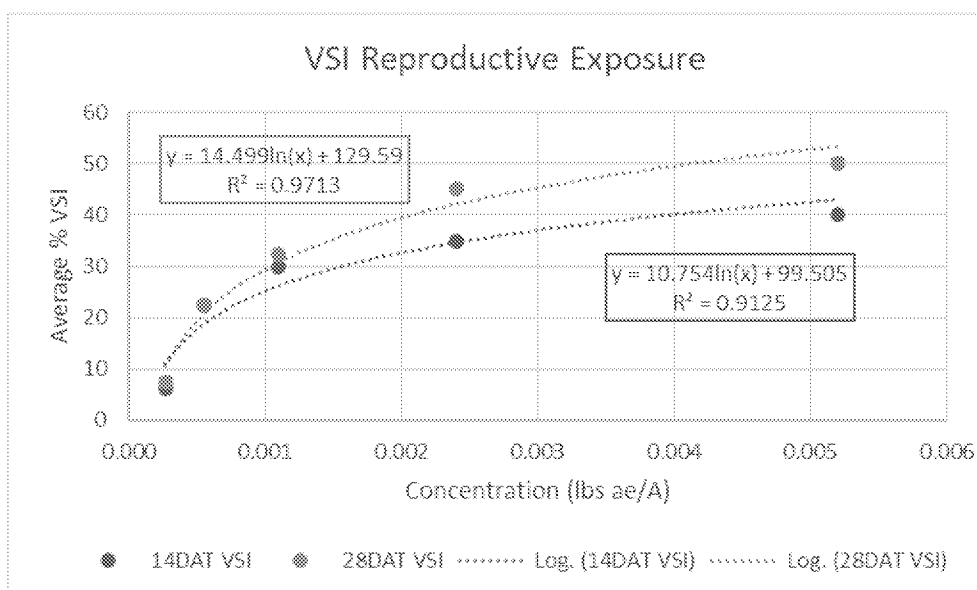
Figure C.21. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a reproductive growth stage exposure.

3.2.5. Fisk, Missouri - MRID 51017506

This study reported the effect of Clarity® formulation (a.i. Dicamba DGA salt) + Roundup PowerMAX® formulation (a.i. Glyphosate potassium salt) + Intact™ (drift reduction agent) on the vegetative vigor and yield of dicamba non-tolerant/glyphosate-tolerant soybean, (*Glycine max*; var. Beck's 4628FP). Nominal concentrations ranged from 0.00030 to 0.0048 lb ae dicamba/A and 0.000675 to 0.0108 lb ae

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glyphosate/A in the spray tank solution. The test concentrations of dicamba and glyphosate were analytically confirmed at all treatment levels.

This study was conducted in field soils located in Missouri (sand, pH and organic matter content not reported).

Two developmental growth stage application timings were assessed, early vegetative growth stage (V3) and flowering reproductive stage (R1). The treatment field was divided into two equal fields with 24 replicate plots for each test; non-dicamba tolerant soybeans were planted on July 14, 2019. The test solutions were applied to the respective field on August 8, 2019 and August 27, 2019 for the vegetative growth test and the reproductive test, respectively. On 28 days after treatment (DAT) for both experiments, soybean plants were measured for height and assessed for visual morphology. Soybean plants were harvested for determination of yield for both studies.

When compared to the negative control, significant inhibitions in soybean plant height were found for both the vegetative growth and reproductive stages. For the vegetative growth stage, significant inhibitions in soybean height were found at 0.00081 lb ae dicamba/A and higher (NOAEC = 0.00035 lbs a.e. dicamba/A). For the reproductive stage, significant inhibitions in soybean height were found at 0.0016 lb ae dicamba/A and higher (NOAEC = 0.00064 lbs a.e. dicamba/A).

When compared to the negative control, no significant inhibitions in soybean yield were found for either the vegetative growth stage exposure trial. For the reproduction stage exposure, the highest tested concentration had a significant reduction in yield as compared to the negative control.

Based on the IC_{25s}, the most sensitive endpoint was day 28-height for the vegetative growth stage exposure, with NOAEC and IC_{25} values of 0.00035 and 0.002 lb ae/A Dicamba, respectively.

Reported VSI included leaf cupping, epinasty of both stems and petioles, and some stunting and were readily apparent at all application rates in soybean plants in the vegetative growth study after 14 and 28 days. Two of the control plots showed 5% VSI on day 28. In the reproductive stage study, some new secondary stem growth was epinastic, some younger pods were curled, and there was compression of the main stem internodes. VSI was evaluated using logistic regression in Excel fit to observed VSI for each test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.24 and C.25** were used to estimate the %VSI for regression based ICx values for plant height and yield. **Table C.23 and C.24** provides the observed (NOAECs) and estimated (ICx) average %VSI for each height and yield endpoint for 14DAT and 28DAT.

Results Synopsis

A summary of the endpoints for height and yield are provided for dicamba (**Table C.23**). Also provided in **Figures C.22 & C.23** are the response relationships between height, VSI, yield, test concentration and evaluation time step. The average %VSI for each height and yield endpoint is provided in **Table C.24**. This study is scientifically sound and is classified as supplemental.

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Table C.23. MRID 51017506: Summary of most sensitive parameters (lb ae/A Dicamba).

Species	Stage	Endpoint	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	14-DAT Height	0.00081	0.00034	0.0027
		28-DAT Height	0.00035	0.00010	0.0020
		Yield	0.0087	NC	NC
	Reproductive	14-DAT Height	0.0016	0.0016	0.0084
		28-DAT Height	0.00064	0.00057	0.0082
		Yield	0.0032	0.0016	0.0055

NC = Not calculable.

Table C.24. MRID 51017506: Summary of Estimated Average % VSI at Endpoint Concentrations provided in Table C.23. (%)

Species	Stage	Endpoint[*]	NOAEC	EC_{05}/IC_{05}	EC_{25}/IC_{25}
Soybean	Vegetative Growth	VSI 14-DAT Height	38	30	47
		VSI 28-DAT Height	20	13	34
		VSI Yield [a]	55 (14DAT) 45 (28DAT)	NC	NC
	Reproductive	VSI 14-DAT Height	23	25	42
		VSI 28-DAT Height	30	22	57
		VSI Yield	33 (14DAT) 45 (28DAT)	25 (14DAT) 35 (28DAT)	38 (14DAT) 52 (28DAT)

[*] Endpoints in **Table C.23** were used to a) provide the observed VSI at the NOAEC, and b) estimate the %VSI at height and yield IC_x endpoints using logistic regression equations fit to study reported VSI on 14-DAT and 28-DAT.
[a] VSI was not assessed at the time of harvest, therefore %VSI for Yield is presented as the observed or predicted %VSI at 14DAT and 28DAT for the Yield endpoints in **Table C.23**.
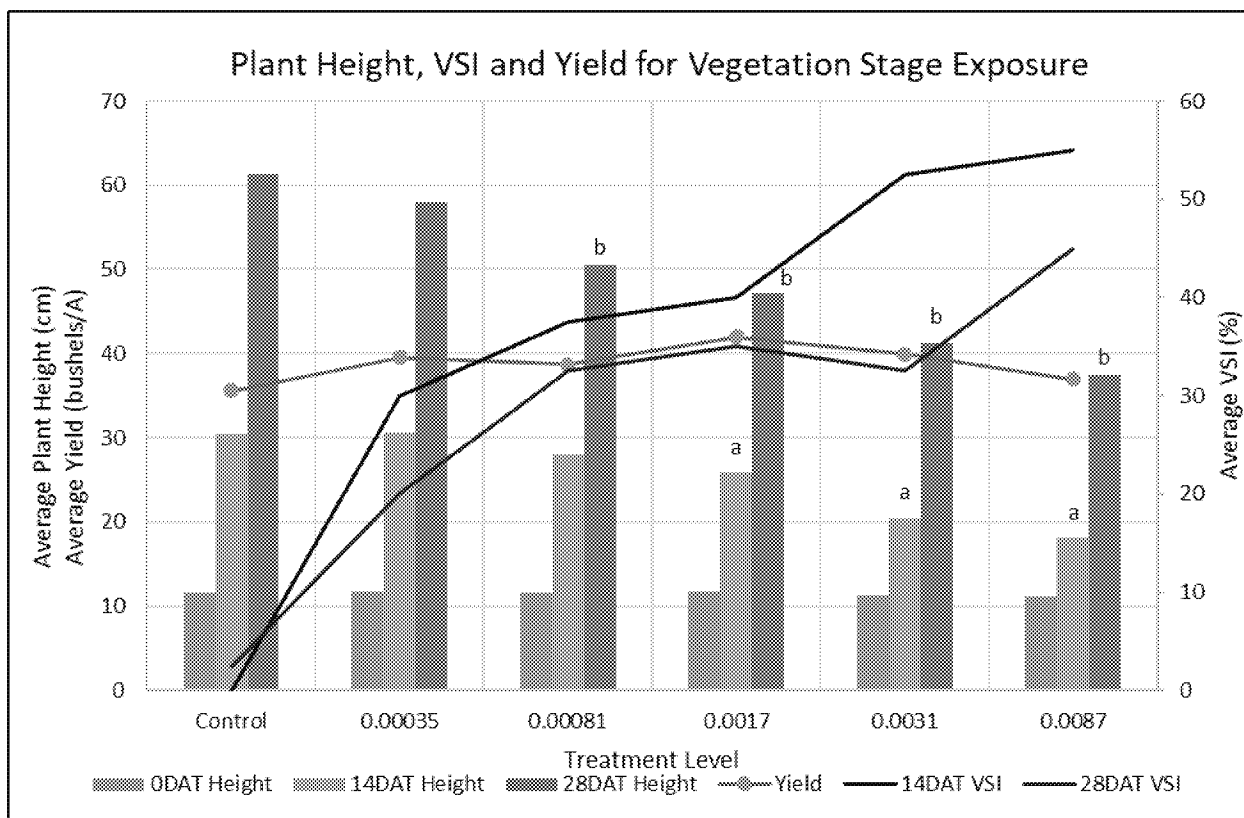
Figure C.22: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during vegetative growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.
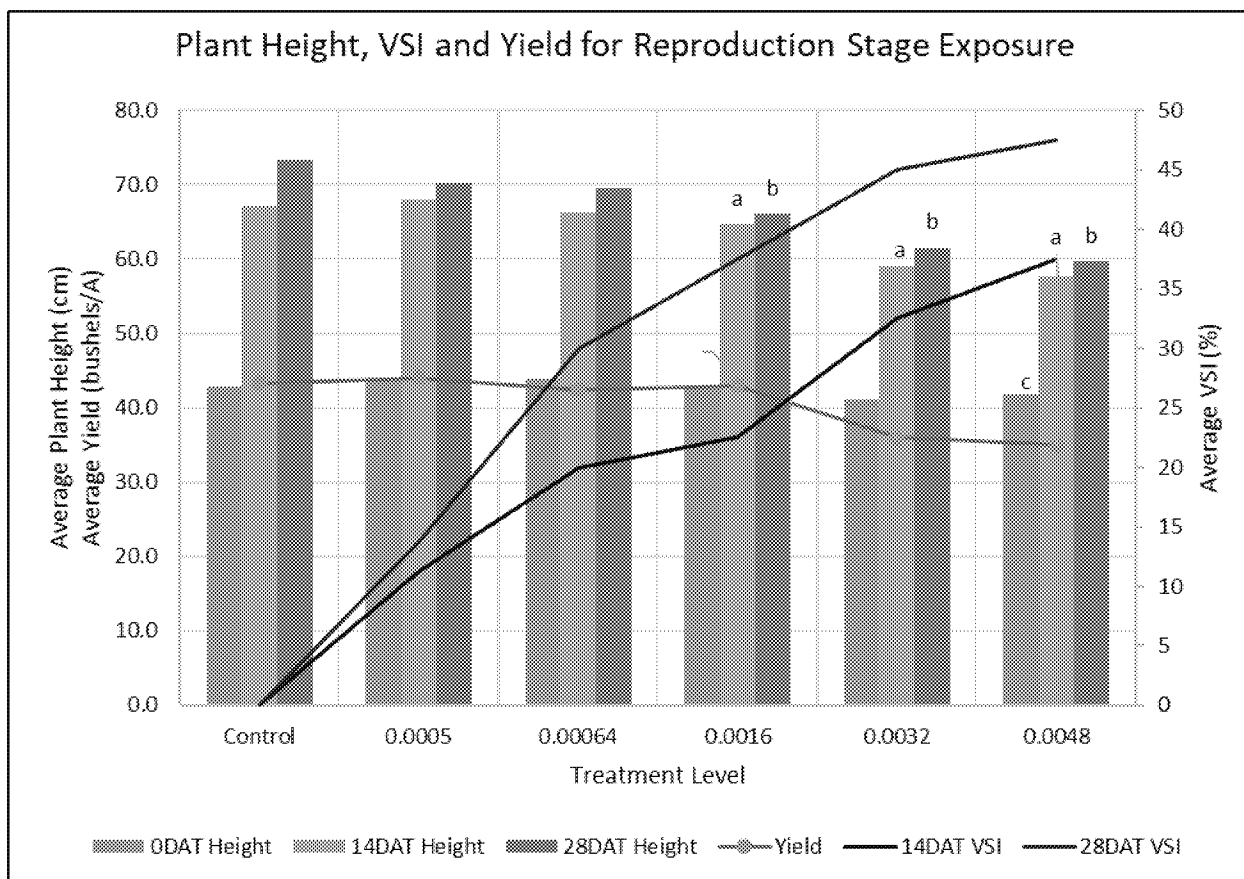
Figure C.23: Relationship of plant height (Day 0, 14, 28), VSI (Day 14, 28) and yield (test termination) for the treatments applied during reproductive growth stages. Note: treatment levels with responses determined to be statistically different from the controls for day 14 height ("a"); day 28 height ("b"), and yield ("c") are indicated.

Evaluation of Visual Signs of Injury (VSI)

Logistic regression was used to fit a regression to observed VSI against test dose. No hypothesis testing was evaluated to establish NOAEC/LOAEC endpoints. Regression equations provided in **Figures C.24 and C.25** were used to estimate the %VSI for regression based ICx values for plant height and yield. See **Table C. 24** for the results of these estimation procedures.

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VSI Vegetative Exposure

y = 8.2212ln(x) + 95.573
R² = 0.9275

y = 6.6214ln(x) + 75.343
R² = 0.8385

Average % VSI

Concentration (lbs ae/A)

● 14DAT VSI ● 28DAT VSI ········· Log. (14DAT VSI) ········· Log. (28DAT VSI)
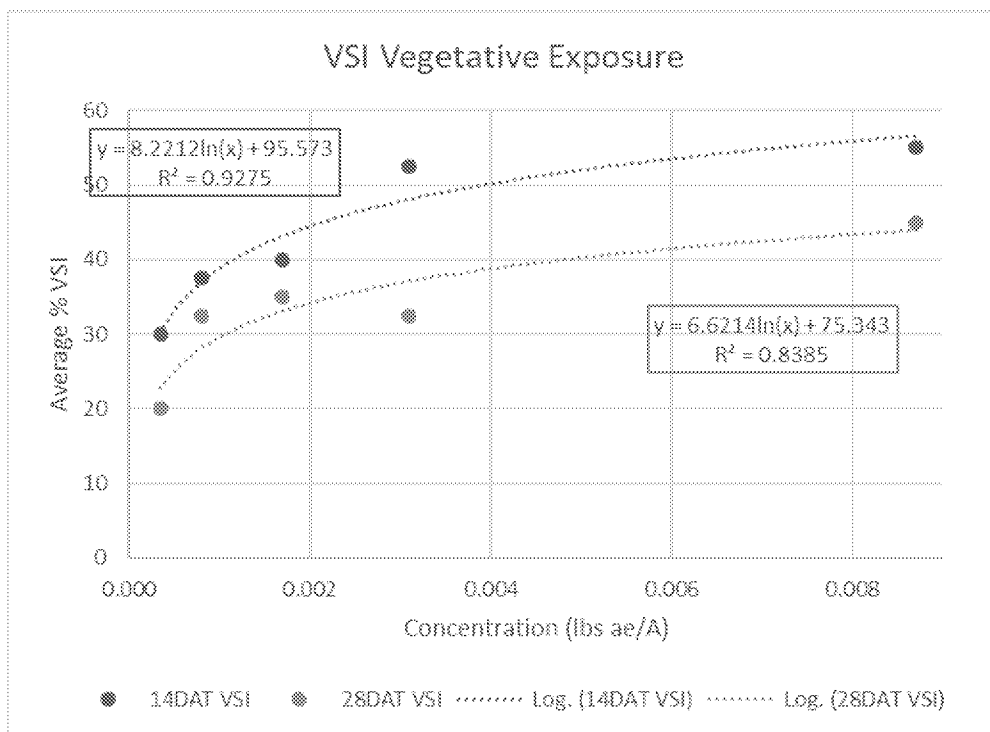
Figure C.24. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a vegetative growth stage exposure.

VSI Reproductive Exposure

y = 12.914ln(x) + 118.63
R² = 0.8721

y = 10.207ln(x) + 91.049
R² = 0.9307

Average % VSI

Concentration (lbs ae/A)

● 14DAT VSI ● 28DAT VSI ········· Log. (14DAT VSI) ········· Log. (28DAT VSI)
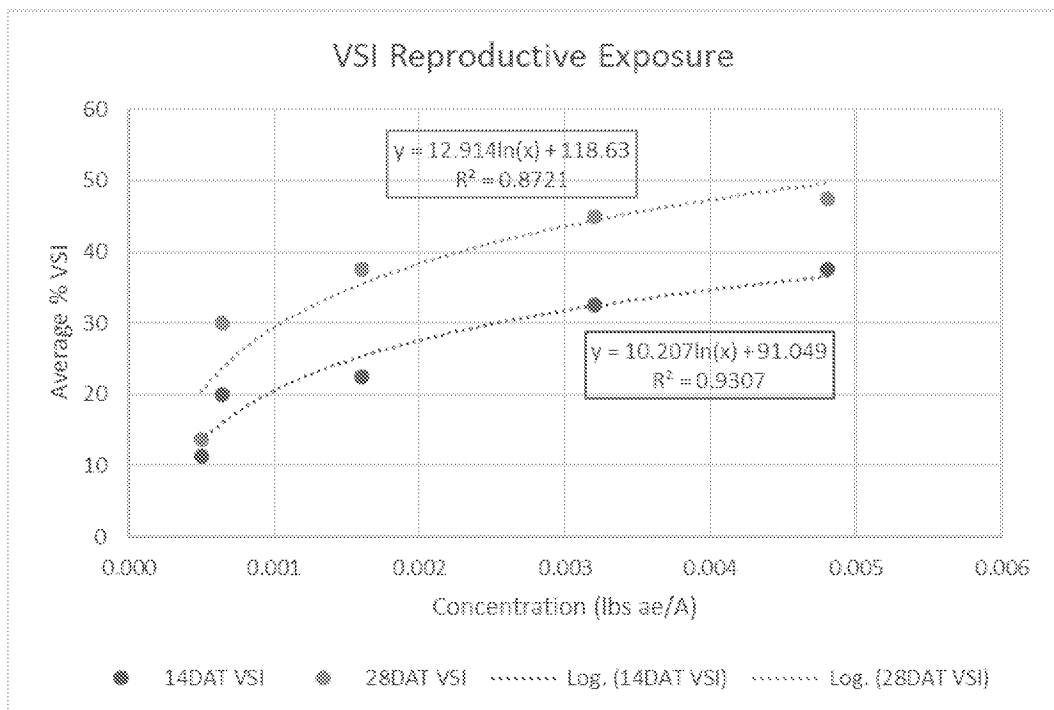
Figure C.25. Logistic regression of %VSI for 14DAT and 28DAT observations of %VSI after a reproductive growth stage exposure.

4. Low tunnel studies

Academic researchers and registrants mentioned field-based toxicity studies referred to as "low-tunnel" studies in several presentations to EPA. (WSSA Presentations to EPA January 16, 2020) The general design consists of several rows of non-dicamba tolerant soybeans covered by a low fabric or plastic tunnel. A test conducted by applying a dicamba formulated product (e.g., XtendiMax; Engenia; XtendiMax + VGX) to one or more seed planting trays filled with only soil. Applications were made at exaggerated rates (*e.g.*, 4 lbs a.e./A). The trays are placed inside of the tunnels and exposure to dicamba that volatilizes from the trays is evaluated. These evaluations generally consider the plant damage along the rows of covered soybeans, such that the distance from the tray to the percent VSI is reported. The studies can be useful when determining if a given formulation results in a vapor exposure (VSI observed) and some relative comparisons between formulations and additives may be possible, but when considering these studies, EPA found their utility in risk assessment limited. Primarily, the design applies dicamba only to a small tray of soil (or two), and the trays do not have any vegetation in them, so it is difficult to relate these tunnel studies to distances of observed effect following large acres of application to a soybean crop. Secondly, the observed effects in the tunnel can be highly influenced based upon field conditions (e.g., wind) and orientation of the tunnels. Therefore, EPA did not utilize the plant effects data from these low tunnel studies in the risk assessments.

5. Vapor exposure

5.1. Greenhouse (humidomes)

EPA used two available greenhouse based humidome studies in the evaluation of the plant height and VSI endpoints following a vapor phase exposure. Both studies were designed such that different combinations of dicamba products and formulations (referred to here as "trials") were applied to petri plates which were placed within the humidome with vegetative vigor growth stage plants. The plants were left in the humidome for a duration of 24 hrs, then were removed and VSI was observed on 14 and 21 days after treatment (DAT). Plant height was also recorded on 21 DAT.

The first of these studies (MRID 49925703) resulted in an IC_{05} for plant height at 35.0 ng a.e./m^3 based on logistic regression of the mean heights from each trial. This corresponded to a VSI of approximately 10% based on the regression of VSI by concentration (Figure XX). Using hypothesis testing, the NOAEC was determined to be 17.7 ng/m^3 with a LOAEC of 539 ng/m^3. The dose spacing was approximately 30x different between the NOAEC and LOAEC, creating uncertainty as to where effects to plants from vapor-phase exposure to dicamba may occur. This uncertainty reduces the confidence in the regression based IC_{05} estimates for plant height and VSI.
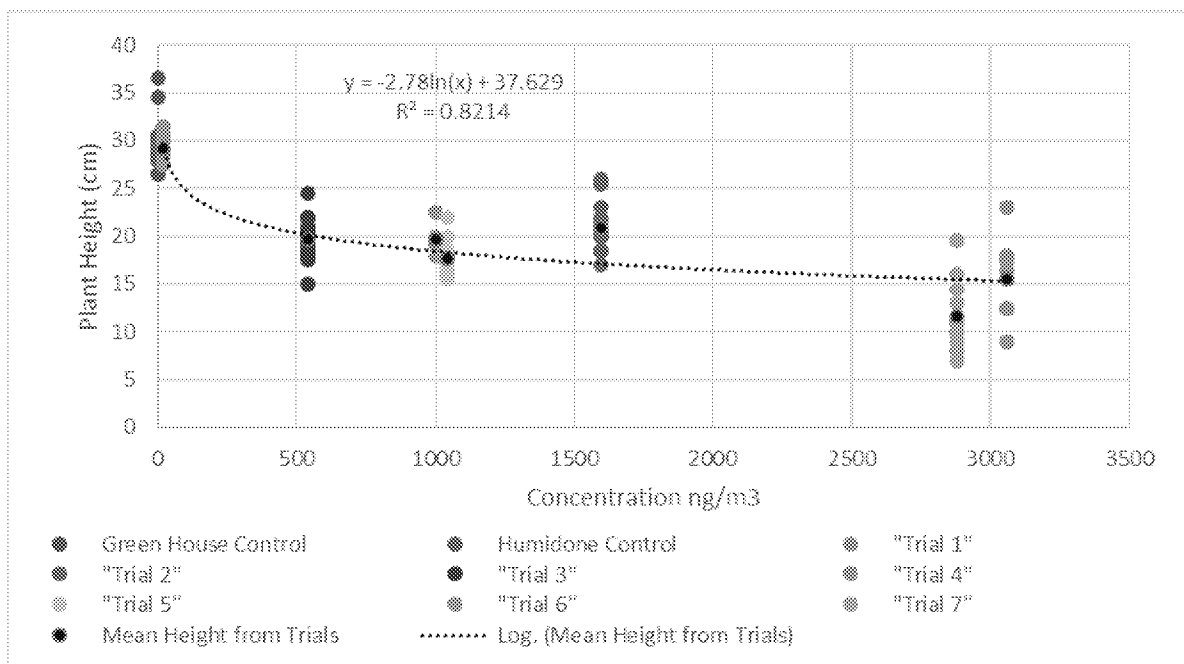
Figure C.26. Reduction of plant height for vapor phase exposure trials in MRID 49925703.
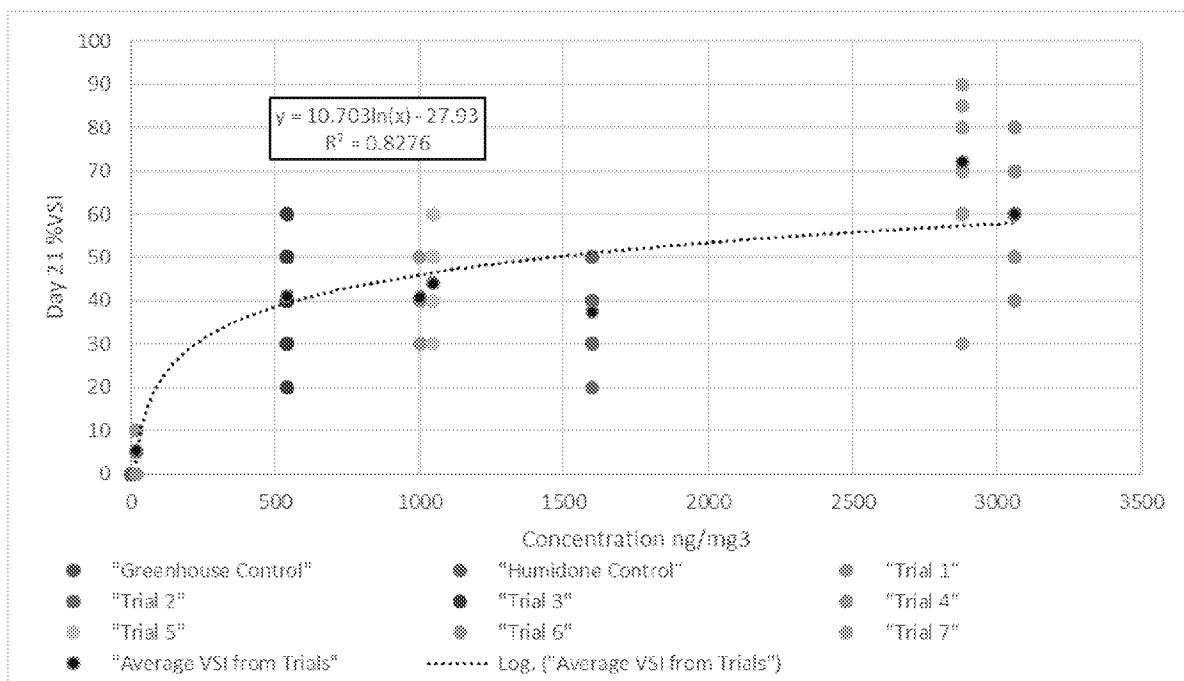
Figure C.27. Observed VSI for vapor phase exposure trials in MRID 49925703.

A follow-up study (MRID 50578901) was submitted by a registrant to address the uncertainty with the dose spacing in the first study. The trials were redesigned to attempt to capture lower exposure concentrations. The results indicated that soybean height was greater than or equal to 238 ng/m3 (12%) compared to control plants (p<0.0001). As a result, the NOAEC was 138 ng/m3 (an approximate 8-fold increase relative to previous NOAEC). Results from this new study fall within

the range of the previous NOAEC and LOAEC endpoints, and with the refined dose spacing, there is greater certainty in the new NOAEC and LOAEC endpoints, compared to the previous vapor phase study. The regression based IC05 estimate for plant height is estimated at 168 ng/m³ which corresponds to approximately 15%VSI 21DAT. The estimated IC_{10} for VSI was estimated to be 110 ng/m³.
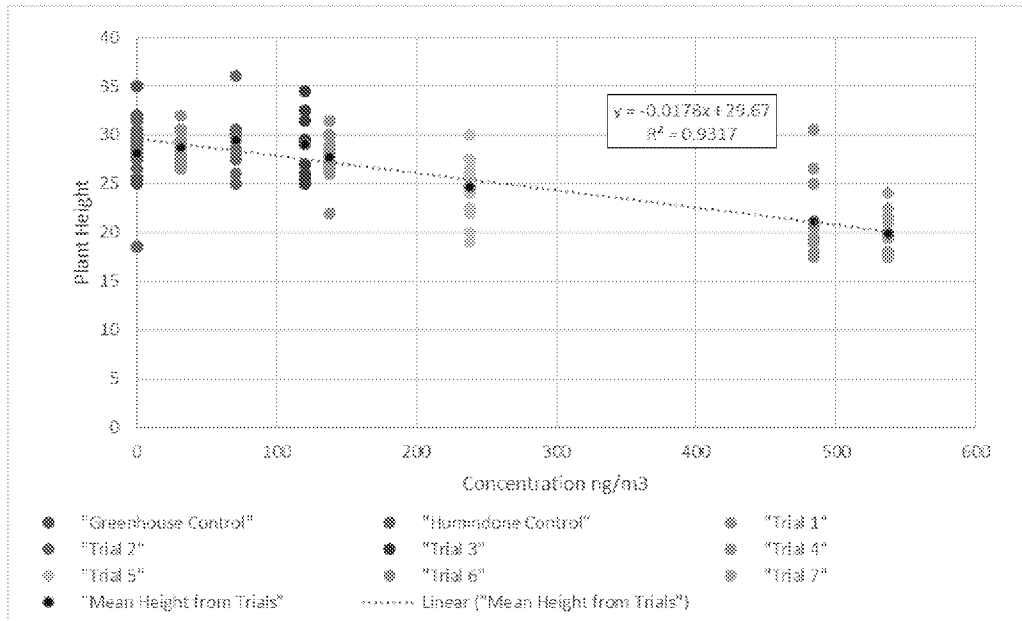
Figure C.28. Reduction of plant height for vapor phase exposure trials in MRID 50578901.
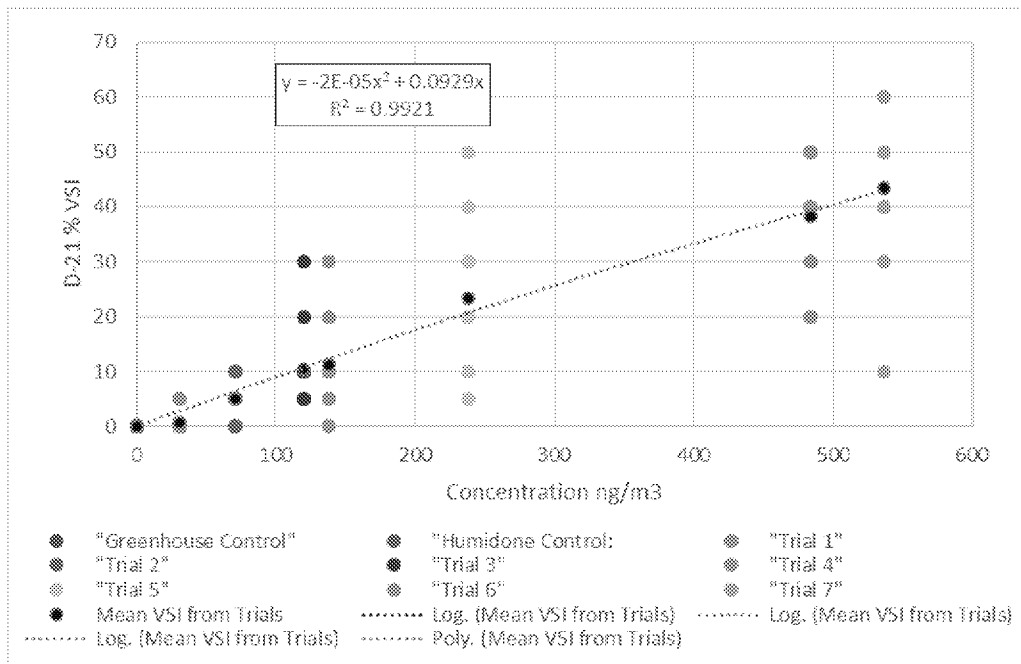
Figure C.29. Observed VSI for vapor phase exposure trials in MRID 50578901.

5.2. Field Study of Vapor Exposure Effects (on treated field).

In 2018 and 2019, Dr. Norsworthy of the University of Arkansas investigated the volatility of dicamba on 200 ft x 200 ft (0.46 A) and 100 ft x 100 ft (0.23 A) fields, respectively, of dicamba-tolerant soybean (approximately 140,000 seeds per acre and in 36 in rows) at the R1 stage (Norsworthy, 2018a-c; Norsworthy, 2020). The pH of the soil was 5.5 and 6.8 in 2018 and 2019, respectively. Fields were treated with XtendiMax, PowerMAX, and Intact at rate of dicamba at 0.5 lbs ae/A on 7/31/2018 and 7/11/2019 between 8 and 9 am. High volume (185 L/min) and low volume (3 L/min) air samplers were placed at a distance of 5 ft from the treated field in the four cardinal directions as well as the four diagonals, and air samples were collected 0-6, 6-12, 12-24, 24-36, 36-48 and 48-72, and 72-96 hours after treatment (HAT), with the 2019 study collecting samples through 48 HAT. Temperatures ranged from $16 - 31°C$ ($61 - 88°F$) and $18 - 29°C$ ($64 - 84°F$) during the study in 2018 and 2019, respectively.

The field studies conducted in 2018 and 2019 included greenhouse grown potted soybean plants (R1 growth stage) which were set above the canopy of the treated soybean crop after application to the soybean field in order to evaluate the plant response to exposure to dicamba related to volatility. Plants were exposed for various cumulative lengths of time (24, 48, 72, 96 hrs) and other trials placed new plants out for 24 hr exposures on day 1, 2, 3, and 4. Each trial provided a measure of VSI as well as plant height. Consistent with other field-based studies, the concentration of dicamba in air (ng/m3) decreases significantly after the first 24 hrs (**Figure C.30**). Evaluation of the plant response for the first 24-hr after application (**Figure C.31**) shows a similar plant response, indicating that the first 24-hrs is the primary time period of significant plant damage, and a slight, non-significant, increase in effect with cumulative exposure duration (**Figure C.32**). These results show a strong positive relationship of plant response (VSI) with cumulative exposure concentration.

EPA combined all of these field tests in a linear regression to evaluate the air concentrations at which a reduction of 5% plant height relative to control plant heights was observed (**Figure C.34**; IC_{05} = 2.4 ng/m3). The poor fit of the regression of plant height reflects the variability in plant height measures under field conditions. EPA compared the relationship of VSI to height (**Figure C.35**) which showed a ratio of 2.8:1 at 5% height (i.e., 14%VSI:5%Height) and suggested that a consistent reduction in plant height started around 20-30%VSI (**Figure C.35**). Lastly, EPA estimated the air concentration (ng/m3) at which 10% VSI would be expected (**Figure C.33**; IC_{10} = 1.7 ng/m3). The 10%VSI estimate was selected based on evaluations described in **Appendix D**, and was used in the comparisons to dicamba concentrations in air (**Appendix H.2**)
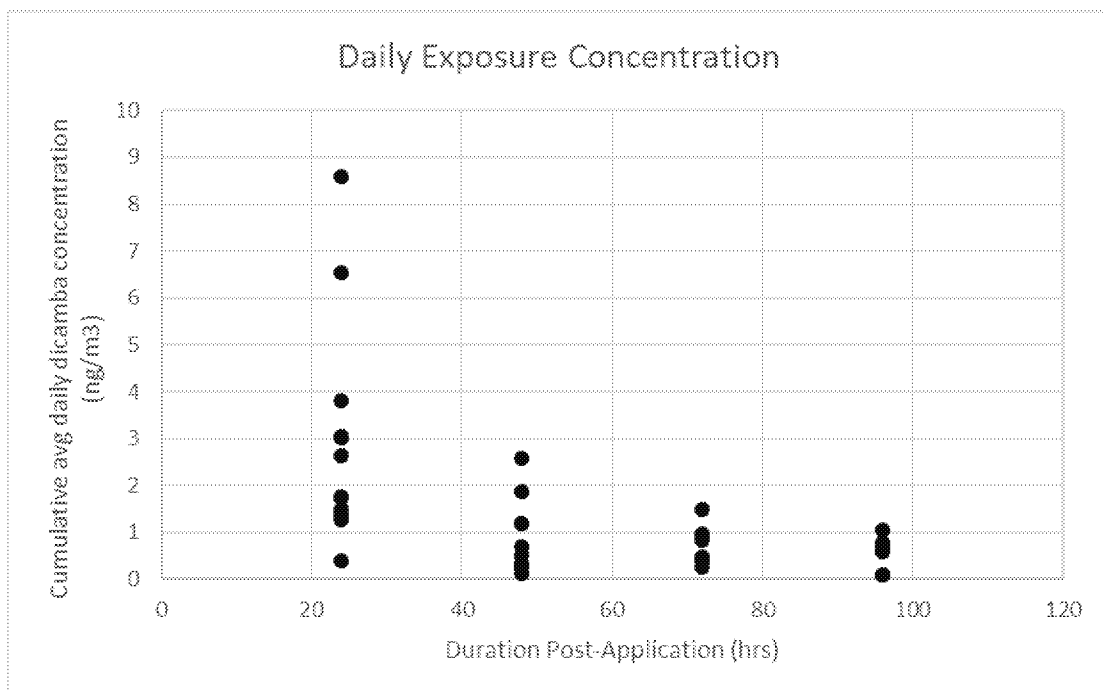
Figure C.30. 24-hr exposure concentrations for 24, 48, 72, and 96 hours after treatment.
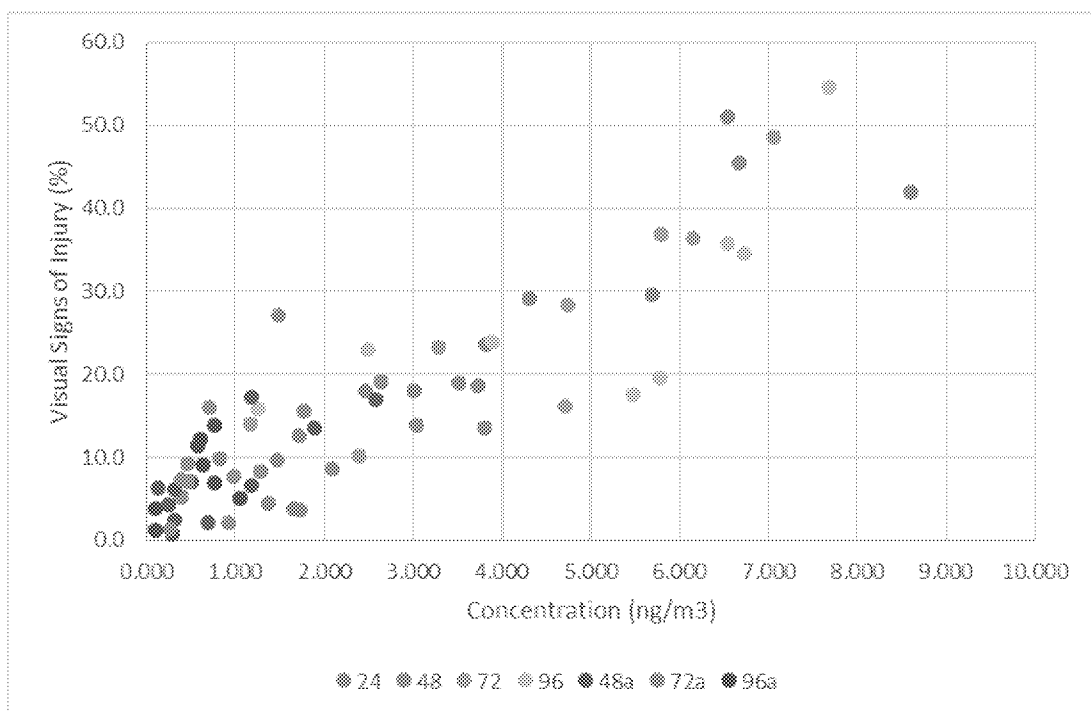
Figure C. 31. Relationship of VSI and air concentration for treatments with 24, 48, 72, and 96 hours exposure durations. Treatments 48a, 72a and 96a were 24-hour exposure durations.
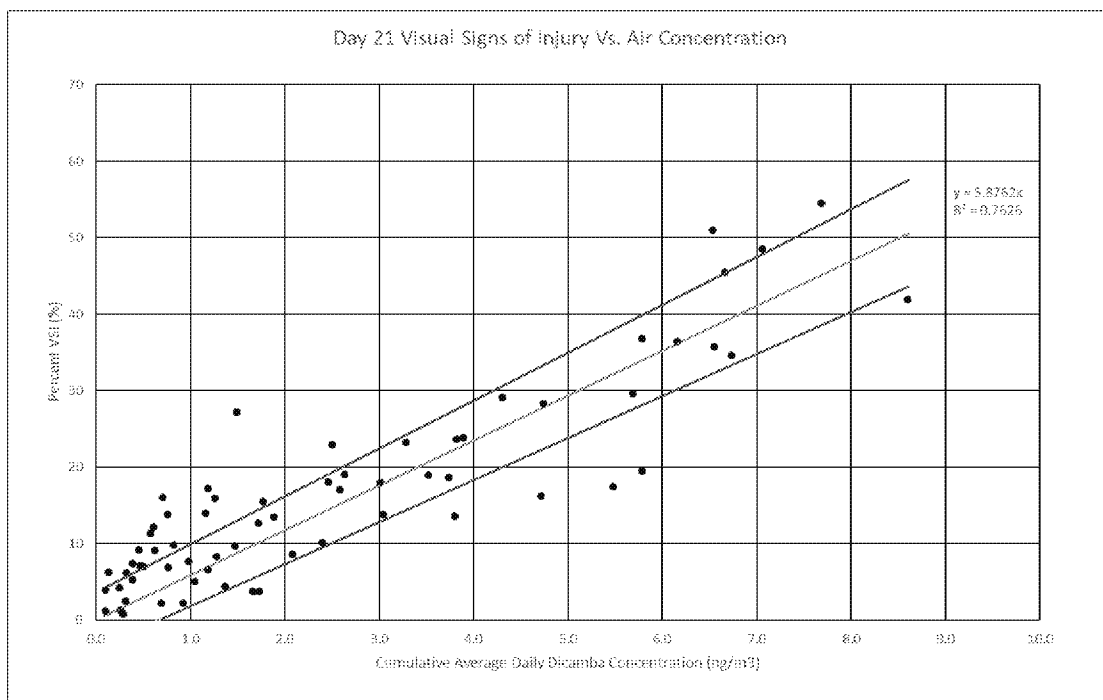
Figure C32. Evaluation of VSI as related to daily exposure to dicamba in air. Linear regression used to estimate the concentration at 10%VSI (orange line is the central tendency of the regression, black lines represent 95% Cis)
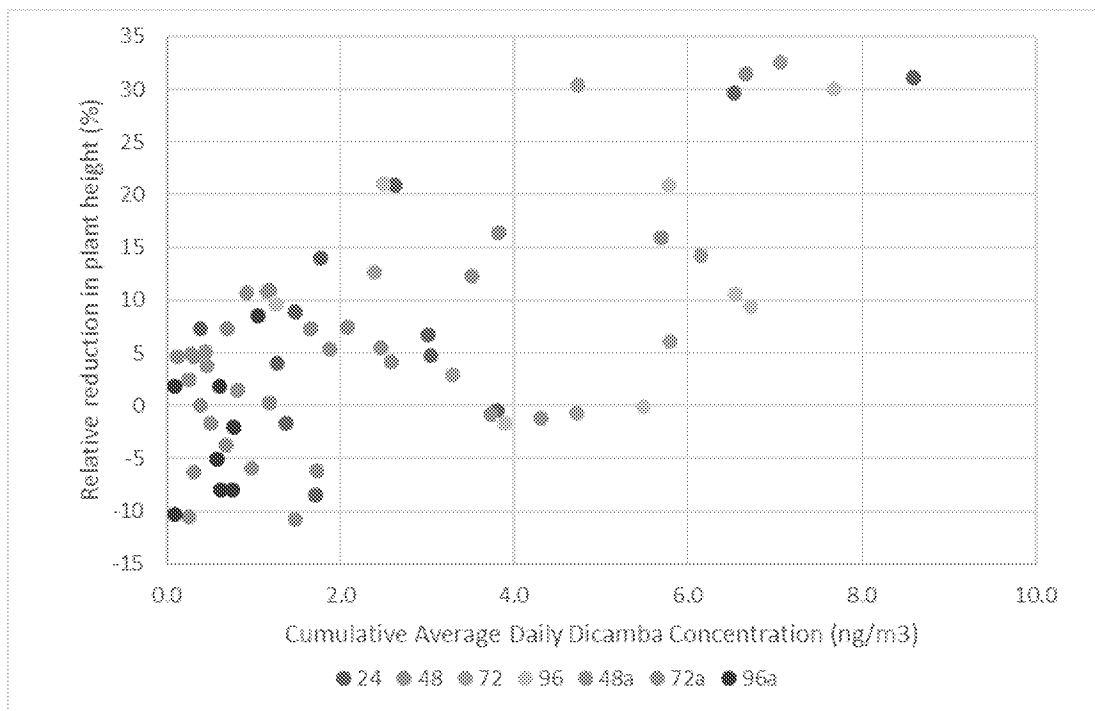
Figure C.33. Relationship of plant height reductions relative to controls and air concentration for treatments with 24, 48, 72, and 96 hours exposure durations. Treatments 48a, 72a and 96a were 24-hour exposure durations.
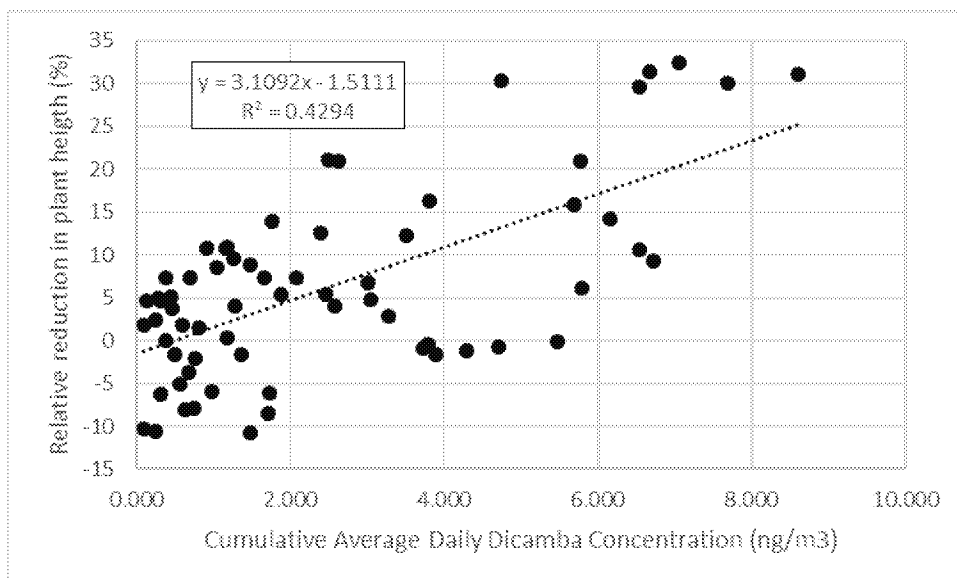
Figure C.34. Evaluation of relative plant height reduction as related to daily exposure to dicamba in air. Linear regression used to estimate the concentration at 5%height.
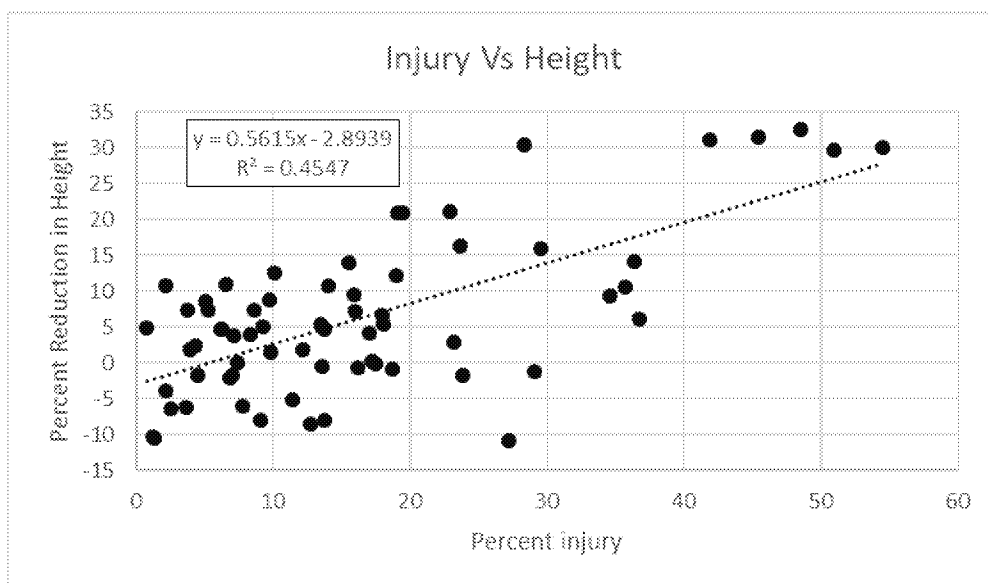
Figure C.35. Evaluation of relative plant height reduction as related to VSI.

Appendix D. Establishment of the VSI Endpoint – Probability Analyses

1. VSI to Plant Height and Plant Yield Ratio Uncertainties, Limitations, and Process

As discussed in Appendix C, the threshold endpoints that are relied upon in this assessment are based on reductions of growth (5% height) and reproduction (5% yield) and are conservatively selected to protect the most sensitive species from potential effect. Therefore, this analysis of VSI to height and VSI to yield is based upon the relationships at the 5% effect level for each endpoint (see **Appendix C.1** for more details on endpoints in risk assessment).

There is considerable overlap in the ranges of VSI:5% height and VSI:5% yield ratios for both V-stage and R-stage plant height and yield measures. This suggests that the data from different plant growth stages in this evaluation can be combined. Potential contributing factors for the range in observations across the studies within each VSI:5%height and VSI:5%yield ratio calculation may be the effects of factors that affect overall growth and maturation of soybeans. These may include soybean variety, meteorological conditions (*e.g.*, temperature and rainfall) and soil conditions (*e.g.*, soil fertility and moisture holding). The effects of these environmental variables among the studies discussed in **Appendix C** and **Appendix E** is not quantitatively known. The available data show that the range for field-derived studies encompasses the ratios derived for the two laboratory studies (e.g., MRID 47815102 and 48718015), where environmental conditions and plant development stage at application were selected to optimize the evaluation of growth effects.

One uncertainty with using this dataset is that none of these studies, with the possible exceptions of Silva *et al* (2018) and the registrant-submitted study using BAPMA salt (MRID 48718015) used the then-registered dicamba formulations for DT-crops (XtendiMax or Engenia). It is unknown the exact impact that the formulation used might have on the nature and extent of toxicity or on the ratio of VSI to apical endpoint. However, it is notable that in the registrant-submitted laboratory studies with DGA (Clarity™) and BAPMA salts (MRIDs 47815102 and 48718015, respectively, both conducted at the same laboratory, but in different years), the formulation used appeared to have near negligible impacts on the effects observed. For example, an application of 0.00026 lb ae/A Clarity™ resulted in a 9.2% inhibition of soybean plant height, relative to controls, while an equivalent rate of BAPMA salt (0.0003 lb ae/A) had a 4.8% inhibition of soybean plant height, relative to controls. Similarly, the ratio of %VSI to %plant height effects was 2.1 and 2.5, respectively for the DGA and BAPMA salt formulations. This suggests that the impact of formulation on toxic effects may be a limited source of variability compared to other factors (*e.g.* study site, researcher, differing study protocols, etc.)

Another uncertainty in the evaluation is the route of exposure. EPA explored all studies conducted in the greenhouse and field with exposures resulting from direct spray, spray drift, and vapor phase exposure. EPA determined that these routes of exposure are in reasonable agreement with regard to the ratio of VSI to 5% height. This is illustrated by **Figure D.1**, which provides the distribution of the different exposure routes (different colors and shapes) across the rank percentile distribution. Each of the exposure routes is generally spread across the distribution suggesting similar variability of the VSI:5% height relationship. The relevance of the 2:1 relationship, indicated by the vertical orange line, represents approximately the 10th percentile of the rank distribution, such that 90% of the compared empirical measures are representing larger ratios (i.e., more than 10% VSI at 5% height and discussed further below), and only 10% suggest a closer relationship between VSI and 5% height. Note that there are limited data evaluating dicamba effects on yield to evaluate these different routes and their

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relationships of ratios, however a similar distribution of ratios is observed (**Figure D.2**) across the direct spray studies (yield studies described in **Appendix C**) and the Off-field movement studies (**Appendix C**). In **Figure D.2**, the 2:1 VSI:5% yield represents the 30th percentile of the rank distribution, suggesting it may not be as protective of the height relationship. Further discussion of process for selecting the 2:1 relationship and the uncertainty in the VSI:5% yield relationship is discussed in **Section C.2**.
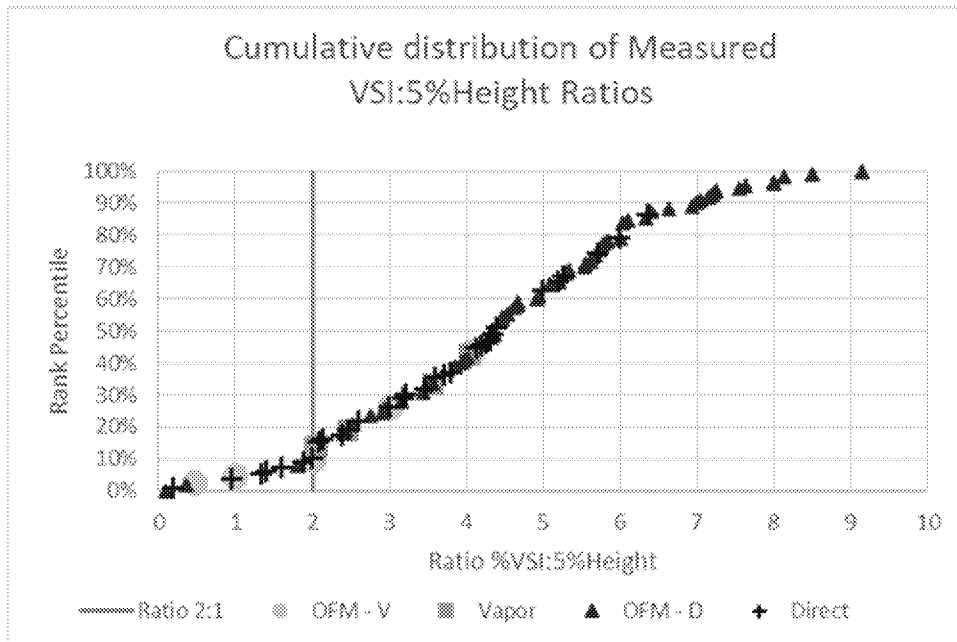
Figure D.1. Rank percentiles of the empirical measures of the ratio of %VSI to 5% Height. A ratio of 2:1 (indicated by the vertical orange line) equates to 10%VSI at 5% height reduction.
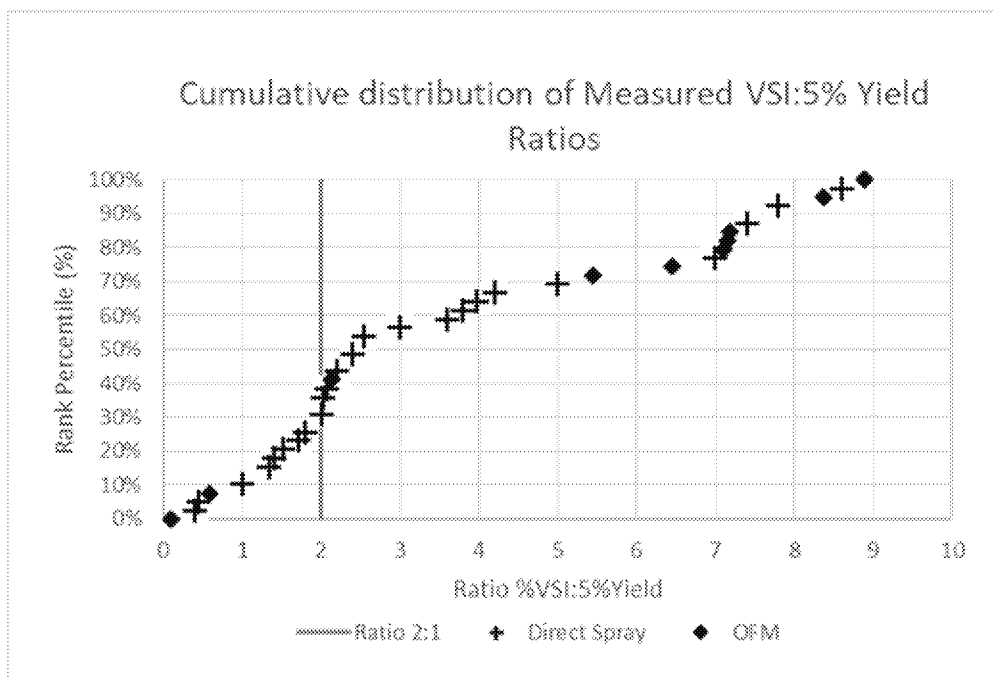
Figure D.2. Rank percentiles of the empirical measures of the ratio of %VSI to 5% Yield. A ratio of 2:1 (indicated by the vertical orange line) equates to 10%VSI at 5% yield reduction.

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Just as growing conditions and cultivars result in varying relationships between VSI and height or yield effects for soybean, it is reasonable to also expect these confounding effects in other non-target plants. The scale with which most of the soybean VSI measurements were determined is suitable for soybean but may not be appropriate for other plant species. While data are available for tomatoes and grapes (e.g., Knezevic), EPA excluded it from further analyses to avoid introduction of additional uncertainty into the relationships of VSI to the measurement endpoints.

In summary, the consideration of the data in **Appendix C** for the evaluation of VSI observations in other field studies of primary and secondary drift of dicamba should recognize:

1. The growth stages of listed plants in the wild will likely not always coincide with that of soybeans or other agricultural crops
2. The ratio between VSI and height or yield for wild plants may occur across the distribution of values identified to date, and may indeed go higher or lower.
3. The environmental conditions affecting plant growth for the soybeans studies in **Appendix C** are likely also important drivers for other plant species
4. Formulation is not expected to be a confounding factor when establishing plant responses to known dicamba doses.
5. VSI scoring is generally conduced in 5% increments (*e.g,* 5, 10, 15, 20, …); selection of the risk assessment VSI endpoint needs to consider the precision for observation of the endpoint.

2. Process for establishing the VSI endpoint relative to 5% Height and Yield Reductions

EPA used Crystal Ball add-in software to Excel to fit distribution functions to the data sets. Crystal Ball enables the user to fit various probability distribution functions to a data set and then sample those distributions thousands of times using Monte Carlo probabilistic algorithms to test the extent to which the selected distributions tend to over or underestimate any segment of the distribution of the variable. Because EPA is interested in reasonable lower bound estimates for the regulatory purposes, the Agency selected an exponential distribution to fit to the data that would be a more accurate representation of the dispersion of data at the lower limits of the distribution. EPA restricted the optional probability functions to only those which could be restricted to a minimum of zero to avoid having distributions with predictions of negative VSI. EPA then tested the predictive quality of the fit distributions by sampling the distributions using Crystal Ball's Monte Carlo random sampling algorithms (random seed, Monte Carlo sampling). EPA compared the lower quantiles of the data, the fit distribution, and the distribution of randomly sampled values to determine if the results produced inconsistent lower quantile values (30%, 20% and 10%). EPA considered the model reasonable if the comparison of the data, the distribution, and the distribution of randomly sampled values were consistent.

2.1. Percent VSI at 5% Height Reduction

Table D.1 provides the VSI:5% height input file for the Crystal Ball analyses. EPA determined that both BetaPERT and Beta exponential functions fit the data equally well, but both slightly underestimate the data across the distribution (**Figures D.3 and D.4**). Because both functions represent the data well, EPA considered the results from both in the setting of the %VSI to represent 5% height reduction.
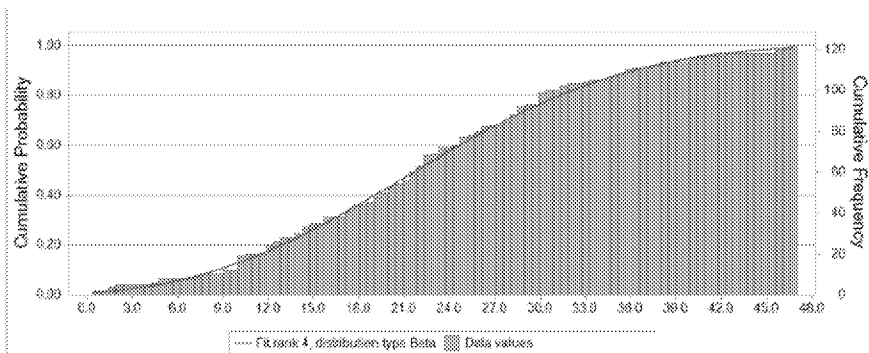
Figure D.3. BetaPERT curve fitting of VSI:5% height data.
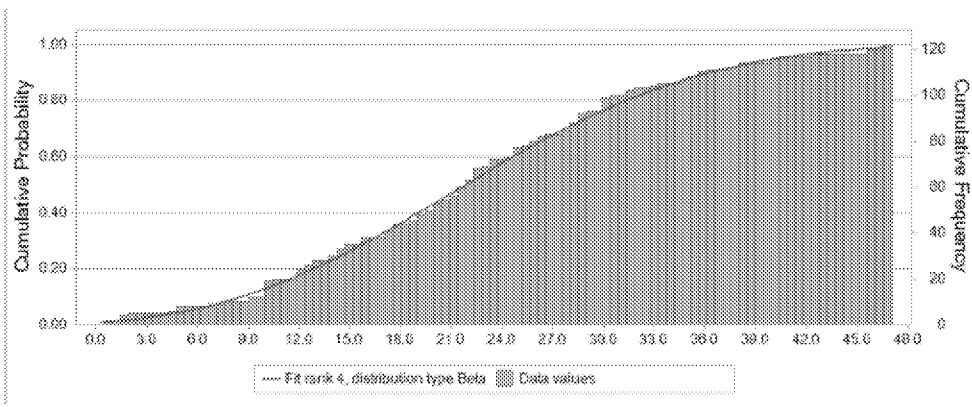
Figure D.4. Beta curve fitting of VSI:5% height data

As anticipated by their nature of being different functions, BetaPERT and Beta produce different %VSI estimates at the 5th percentile (the reasonable lower bound estimate; **Table D.2**). Based on the BetaPERT distribution, the 5th percentile is 7.7% VSI and the 10th is 10.3 %VSI, whereas with the Beta distribution the 5th percentile is approximately 15% VSI and 10% VSI is at the 1st percentile.

Because the scale of measurements of %VSI is typically at 5% intervals, it is important to select a %VSI representing a similar resolution (e.g., 5% increments) which is relatable to how it may be used for defining distances (**Appendix E**) or determining a severity of impact in the field. Based on the two selected models, the three %VSI options to select from are 5%, 10% and 15% VSI. The estimates of the BetaPERT distribution having a range of 7.7-10.3% VSI between the 5th and 10th percentiles. Rounding the %VSI to the 5% increments would result in both being 10% VSI. The Beta distribution estimated 10% VSI at the 1st percentile (such that 99% of %VSI measures at 5% height would be higher than 10%VSI), this is more protective than the BetaPERT result. The 5th percentile of the Beta distribution is approximately 15% VSI, as compared to the BetaPERT distribution 15% VSI is at the 25th percentile (only 75% of %VSI estimates at 5% height would be higher). Based on these considerations, EPA determined the measurement of 10% VSI as the endpoint to represent a 5% reduction of height.

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Table D.1. Summary of the Percentiles of %VSI at 5% height as predicted by BetaPERT and Beta distributional functions (full distributions provided at the end of this Appendix).

Percentile	BetaPERT distribution estimated %VSI	Beta distribution estimated %VSI
0%	0	0
1%	4.1	10.0
5%	7.7	14.5
10%	10.3	17.2
15%	12.3	19.2
20%	14.1	20.9
25%	15.6	22.3

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Table D.2. VSI to Plant Height Relationships Estimated from the available literature. EPA included studies that measured plant responses following direct spray in greenhouse and field, vapor phase exposure in humidome and field, and from off-site transport of spray drift (D) and volatility (V) (Off-Field Movement Studies, OFM).

Study	Exposure	Trial	% VSI at 5% Height
da Silva 2018	Direct		4.4
da Silva 2018	Direct		33.6
Foster & Griffen	Direct		46.6
Foster & Griffen	Direct		47.0
Growe 2017	Direct	Rocky Mount	4.8
Growe 2017	Direct	Rocky Mount	10.4
Growe 2017	Direct	Rocky Mount	15.9
Growe 2017	Direct	Kinston	16.1
Growe 2017	Direct	Rocky Mount	17.3
Growe 2017	Direct	Kinston	20.6
Growe 2017	Direct	Kinston	21.0
Growe 2017	Direct	Lewiston	21.3
Growe 2017	Direct	Lewiston	21.5
Growe 2017	Direct	Lewiston	21.7
Growe 2017	Direct	Kinston	26.3
Growe 2017	Direct	Lewiston	28.5
Jones ch1	OFM	1	22.36
Jones ch1	OFM	2	9.04
Jones ch1	OFM	3	12.02
Jones ch1	OFM	4	14.56
Jones ch1	OFM	5	13.82
Jones ch1	OFM	6	1.82
Jones ch1	OFM	7	0.00
Jones ch1	OFM	8	12.60
Jones ch1	OFM	9	23.35
Jones ch1	OFM	10	45.79
Jones ch1	OFM	11	38.17
Jones ch4	OFM – D	7	0.0
Jones ch4	OFM – D	6	1.8
Jones ch4	OFM – D	2	9.0
Jones ch4	OFM – D	3	12.0
Jones ch4	OFM – D	8	12.6
Jones ch4	OFM – D	5	13.8
Jones ch4	OFM – D	4	14.6
Jones ch4	OFM – D	1	22.4
Jones ch4	OFM – D	9	23.4
Jones ch4	OFM – D	11	38.2
Jones ch4	OFM – D	10	45.8
MRID 47815102	Direct		10.7
MRID 48718015	Direct		12.3
MRID 49925703	Vapor	mean	10.1

Study	Exposure	Trial	% VSI at 5% Height
MRID 49925703	Vapor	mean	10.3
MRID 49953901	Direct		18.6
MRID 50102116	Direct		31.8
MRID 50578901	Vapor	mean	17.8
MRID 50578901	Vapor	mean	20.2
MRID 50958203	OFM – D	Tavium MS NE1	21.6
MRID 50958203	OFM – D	Tavium MS NE2	22.4
MRID 50958203	OFM – D	Tavium MS NE3	27.8
MRID 50958203	OFM – D	Tavium MS NE2	28.7
MRID 50958203	OFM – D	Tavium MS NE1	32
MRID 50958203	OFM – D	Tavium MS NE3	35.8
MRID 50958205	Direct	Tavium Yield MO	13
MRID 50958205	Direct	Tavium Yield MO	22
MRID 50958205	Direct	Tavium Yield MO	25
MRID 50958205	Direct	Tavium Yield MO	30
MRID 50958206	Direct	Tavium Yield MS	10
MRID 50958206	Direct	Tavium Yield MS	15
MRID 50958206	Direct	Tavium Yield MS	26
MRID 50958206	Direct	Tavium Yield MS	30
MRID 51017501	OFM – V	XtendiMax MS DWA	2.3
MRID 51017501	OFM – V	XtendiMax MS DWB	5
MRID 51017501	OFM – V	XtendiMax MS DWA	10
MRID 51017501	OFM – V	XtendiMax MS DWB	10
MRID 51017501	OFM – V	XtendiMax MS UWB	15
MRID 51017501	OFM – D	XtendiMax MS NE	17.2
MRID 51017501	OFM – V	XtendiMax MS UWB	20.4
MRID 51017501	OFM - D	XtendiMax MS DWA	22.7
MRID 51017501	OFM - D	XtendiMax MS LWA	24.7
MRID 51017501	OFM - D	XtendiMax MS LWB	28.1
MRID 51017501	OFM - D	XtendiMax MS LWA	28.9
MRID 51017501	OFM - D	XtendiMax MS DWB	31.7
MRID 51017501	OFM - D	XtendiMax MS DWB	34.7
MRID 51017501	OFM - D	XtendiMax MS LWB	35
MRID 51017501	OFM - D	XtendiMax MS DWC	36.3
MRID 51017501	OFM - D	XtendiMax MS DWA	37.8
MRID 51017501	OFM - D	XtendiMax MS DWC	42.5
MRID 51017502	OFM - D	XtendiMax IL LWA	14.7
MRID 51017502	OFM - D	XtendiMax IL DWC	15.8
MRID 51017502	OFM - D	XtendiMax IL DWB	17.8
MRID 51017502	OFM - D	XtendiMax IL LWB	19.3
MRID 51017502	OFM - D	XtendiMax IL DWA	19.9
MRID 51017502	OFM - D	XtendiMax IL LWB	20.1
MRID 51017502	OFM - D	XtendiMax IL DWC	21.8
MRID 51017502	OFM - D	XtendiMax IL Ediag	22.7
MRID 51017502	OFM - D	XtendiMax IL DWB	23.1

Study	Exposure	Trial	% VSI at 5% Height
MRID 51017502	OFM - D	XtendiMax IL LWA	24.7
MRID 51017502	OFM - D	XtendiMax IL Ediag	28.1
MRID 51017502	OFM - D	XtendiMax IL DWA	40
MRID 51017504	DIrect	Yield MS	7
MRID 51017504	DIrect	Yield MS	8
MRID 51017504	DIrect	Yield MS	19
MRID 51017504	DIrect	Yield MS	19
MRID 51017505	DIrect	Yield IL	10
MRID 51017505	DIrect	Yield IL	18
MRID 51017505	DIrect	Yield IL	22
MRID 51017505	DIrect	Yield IL	30
MRID 51017506	DIrect	Yield MO	13
MRID 51017506	DIrect	Yield MO	22
MRID 51017506	DIrect	Yield MO	25
MRID 51017506	DIrect	Yield MO	30
MRID 51049002	OFM - D	Engenia MO DWB	28.4
MRID 51049002	OFM - D	Engenia MO DWC	28.8
MRID 51049002	OFM - D	Engenia MO DWA	30.2
MRID 51049002	OFM - D	Engenia MO DWB	30.5
MRID 51049003	OFM - D	Engenia MS DWA	23.4
MRID 51049003	OFM - D	Engenia MS NE	24.6
MRID 51049003	OFM - D	Engenia MS DWC	26.5
MRID 51049003	OFM - D	Engenia MS DWB	27.7
MRID 51049003	OFM - D	Engenia MS DWC	29.2
MRID 51049003	OFM - D	Engenia MS LWB	30
MRID 51049003	OFM - D	Engenia MS NE	33.2
MRID 51049003	OFM - D	Engenia MS DWA	35.3
MRID 51049003	OFM - D	Engenia MS DWB	36
MRID 51049003	OFM - D	Engenia MS LWB	40
MRID 51049004	OFM - D	Engenia IL DWC	17.4
MRID 51049004	OFM - D	Engenia IL DWB	19.7
MRID 51049004	OFM - D	Engenia IL DWC	25.4
MRID 51049004	OFM - D	Engenia IL DWB	26
MRID 51049004	OFM - D	Engenia IL DWA	26.7
MRID 51049004	OFM - D	Engenia IL DWA	40.7
Norsworthy 2019	Vapor		12.3

2.1.1. Crystal Ball Output – VSI:5% Plant Height (BetaPERT Distribution)

Summary:
Entire range is from 0.87 to
48.65
Base case is
1.00
After 10,000 trials, the std. error of the mean is 0.09
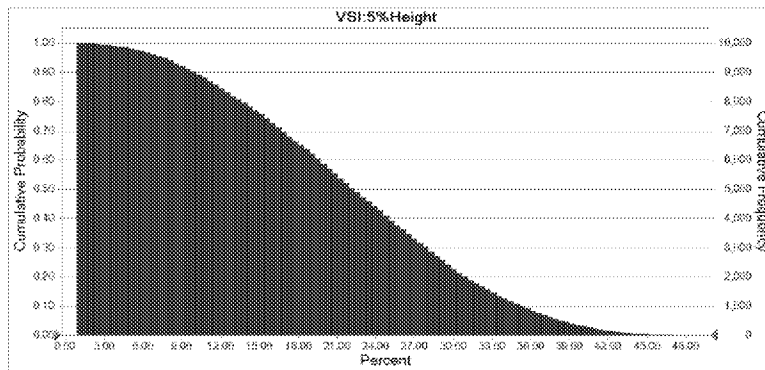
Statistics:	Forecast values
Trials	10,000
Base Case	1.00
Mean	22.66
Median	22.42
Mode	---
Standard Deviation	9.42
Variance	88.79
Skewness	0.1099
Kurtosis	2.34
Coeff. of Variation	0.4158
Minimum	0.87
Maximum	48.65
Range Width	47.78
Mean Std. Error	0.09

Assumption: VSI:5%Height

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	21.60
Maximum	50.12

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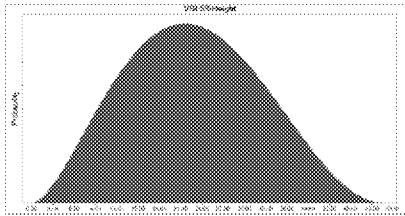
Statistics:

	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	22.66	22.75
Median	22.42	22.48
Mode	---	21.60
Standard Deviation	9.42	9.43
Variance	88.79	88.95
Skewness	0.1099	0.1223
Kurtosis	2.34	2.35
Coeff. of Variation	0.4158	0.4145
Minimum	0.87	0.00
Maximum	48.65	50.12
Range Width	47.78	50.12
Mean Std. Error	0.09	---

Assumption: VSI:5%Height (cont'd)

Percentiles:

	Assumption values	Distribution
0%	0.87	0.00
1%	3.94	4.08
2%	5.29	5.34
3%	6.33	6.28
4%	7.06	7.05
5%	7.76	7.72
6%	8.35	8.33
7%	8.77	8.88
8%	9.26	9.39
9%	9.70	9.87
10%	10.16	10.32
11%	10.60	10.76
12%	10.99	11.17
13%	11.40	11.57
14%	11.72	11.96
15%	12.09	12.33
16%	12.36	12.69
17%	12.71	13.04
18%	13.09	13.39
19%	13.46	13.72
20%	13.82	14.05
21%	14.21	14.38
22%	14.57	14.69

23%	14.85	15.01
24%	15.19	15.31
25%	15.54	15.62
26%	15.80	15.91
27%	16.13	16.21
28%	16.40	16.50
29%	16.65	16.79
30%	16.96	17.08
31%	17.24	17.36
32%	17.52	17.64
33%	17.82	17.92
34%	18.08	18.19
35%	18.44	18.47
36%	18.75	18.74
37%	19.01	19.01
38%	19.29	19.28
39%	19.55	19.55
40%	19.75	19.82
41%	20.02	20.09
42%	20.25	20.36
43%	20.55	20.62
44%	20.85	20.89
45%	21.12	21.15
46%	21.38	21.42
47%	21.65	21.68
48%	21.88	21.95
49%	22.16	22.22
50%	22.42	22.48
51%	22.75	22.75
52%	23.02	23.01
53%	23.29	23.28
54%	23.58	23.55
55%	23.82	23.82
56%	24.13	24.09
57%	24.42	24.36
58%	24.69	24.63
59%	24.96	24.90
60%	25.21	25.18
61%	25.47	25.46
62%	25.73	25.74
63%	26.05	26.02
64%	26.36	26.30
65%	26.63	26.59
66%	26.88	26.88
67%	27.15	27.17
68%	27.46	27.46
69%	27.76	27.76
70%	28.11	28.06

71%	28.37	28.36
72%	28.64	28.67
73%	28.92	28.99
74%	29.23	29.31
75%	29.55	29.63
76%	29.82	29.96
77%	30.13	30.29
78%	30.45	30.64
79%	30.80	30.99
80%	31.12	31.34
81%	31.50	31.71
82%	31.89	32.08
83%	32.26	32.47
84%	32.69	32.87
85%	33.15	33.28
86%	33.55	33.70
87%	33.94	34.14
88%	34.41	34.60
89%	34.92	35.09
90%	35.44	35.59
91%	36.06	36.13
92%	36.55	36.70
93%	37.18	37.31
94%	37.84	37.98
95%	38.56	38.72
96%	39.29	39.56
97%	40.36	40.53
98%	41.49	41.74
99%	43.33	43.44
100%	48.65	50.12

2.1.2. Crystal Ball Output – VSI:5% Plant Height (Beta Distribution)

Forecast: VSI:5%Height

Summary:
Entire range is from 2.62 to
59.35
Base case is
1.00

After 10,000 trials, the std. error of the mean is 0.09
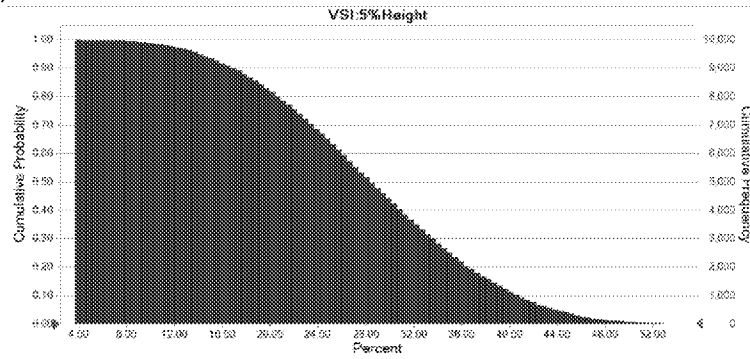
Statistics:	Forecast values
Trials	10,000
Base Case	1.00
Mean	28.94
Median	28.64
Mode	---
Standard Deviation	9.03
Variance	81.46
Skewness	0.1357
Kurtosis	2.61
Coeff. of Variation	0.3119
Minimum	2.62
Maximum	59.35
Range Width	56.73
Mean Std. Error	0.09

Assumption: VSI:5%Height

Beta distribution with parameters:
Minimum	0.00
Maximum	68.59
Alpha	5.491708665
Beta	7.571979744

201
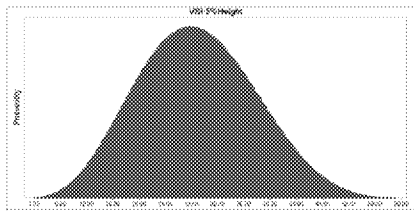
Statistics:	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	28.94	28.83
Median	28.64	28.55
Mode	---	27.84
Standard Deviation	9.03	9.03
Variance	81.46	81.50
Skewness	0.1357	0.1606
Kurtosis	2.61	2.66
Coeff. of Variation	0.3119	0.3131
Minimum	2.62	0.00
Maximum	59.35	68.59
Range Width	56.73	68.59
Mean Std. Error	0.09	---

Assumption: VSI:5%Height (cont'd)

Percentiles:	Assumption values	Distribution
0%	2.62	0.00
1%	10.27	10.00
2%	11.87	11.66
3%	12.99	12.80
4%	13.73	13.69
5%	14.38	14.45
6%	14.96	15.11
7%	15.56	15.70
8%	16.17	16.24
9%	16.75	16.74
10%	17.17	17.20
11%	17.70	17.64
12%	18.06	18.05
13%	18.47	18.45
14%	18.85	18.83
15%	19.21	19.19
16%	19.61	19.55
17%	19.92	19.89
18%	20.27	20.22
19%	20.61	20.54
20%	20.91	20.85

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21%	21.19	21.15
22%	21.57	21.45
23%	21.85	21.74
24%	22.15	22.03
25%	22.45	22.31
26%	22.70	22.59
27%	22.97	22.86
28%	23.23	23.13
29%	23.50	23.40
30%	23.79	23.66
31%	24.07	23.92
32%	24.31	24.17
33%	24.56	24.43
34%	24.79	24.68
35%	25.04	24.93
36%	25.31	25.18
37%	25.57	25.42
38%	25.82	25.67
39%	26.05	25.91
40%	26.27	26.15
41%	26.51	26.39
42%	26.74	26.63
43%	26.98	26.87
44%	27.17	27.11
45%	27.43	27.35
46%	27.67	27.59
47%	27.93	27.83
48%	28.20	28.07
49%	28.40	28.31
50%	28.64	28.55
51%	28.88	28.78
52%	29.15	29.02
53%	29.42	29.26
54%	29.69	29.51
55%	29.96	29.75
56%	30.22	29.99
57%	30.46	30.23
58%	30.68	30.48
59%	30.92	30.73
60%	31.15	30.98
61%	31.39	31.23
62%	31.65	31.48
63%	31.90	31.74
64%	32.20	31.99
65%	32.47	32.25
66%	32.76	32.52
67%	32.98	32.78
68%	33.26	33.05

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69%	33.55	33.32
70%	33.83	33.60
71%	34.11	33.88
72%	34.39	34.17
73%	34.64	34.46
74%	34.93	34.75
75%	35.22	35.06
76%	35.51	35.36
77%	35.81	35.68
78%	36.13	36.00
79%	36.42	36.33
80%	36.81	36.67
81%	37.22	37.02
82%	37.55	37.38
83%	38.00	37.75
84%	38.36	38.14
85%	38.77	38.54
86%	39.19	38.96
87%	39.61	39.40
88%	40.06	39.86
89%	40.49	40.34
90%	40.90	40.86
91%	41.38	41.41
92%	41.97	42.01
93%	42.63	42.66
94%	43.40	43.39
95%	44.16	44.20
96%	45.08	45.15
97%	45.98	46.29
98%	47.49	47.77
99%	49.69	50.02
100%	59.35	68.59

2.2. Percent VSI at 5% Yield Reduction

The empirical data of %VSI to height (**Table D.3**) is not normally distributed and appears to be bimodal (having two distinct frequency peaks; **Figure D.5**). Because of the nature of this distribution the fit of probablity distributions in Crystal Ball were not strong (**Figures D.6 & D.7**).

As described in **Appendix C** the endpoints for plant height are equivalent and therefore considered protective of yield. Since the distributional approach to establishing the %VSI to 5% yield is less confident because of the bimodal relationship described above, EPA relied on the 10%VSI threshold to represent both height and yield. The 10% VSI threshold is a reasonablly protective threhold for 5% yield with roughly 80% of the ratios of %VSI to 5% yield being greater than 2:1 (or 10%VSI:5% yield).
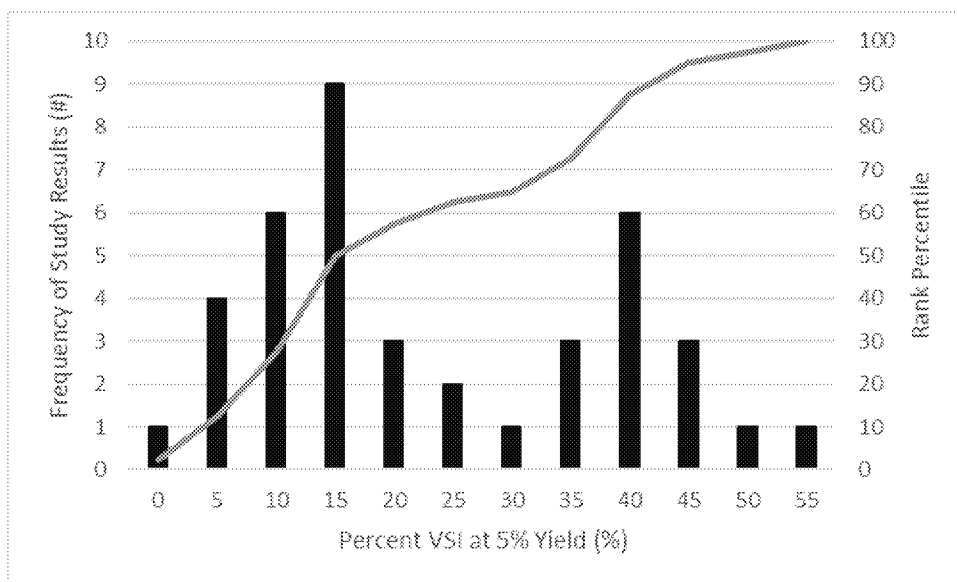
Figure D.5. Frequency distribution (black bars) and rank percentile (orange line) of the %VSI to 5% yield illustrating the bimodal nature of the available dataset.
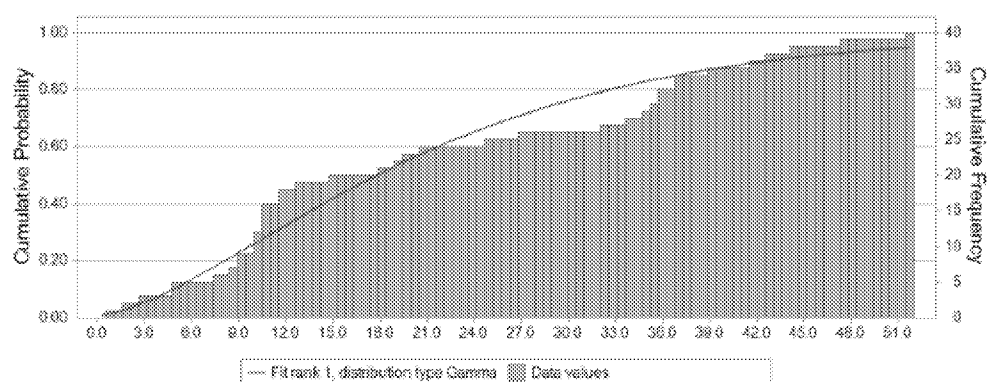
Figure D.6. Illustration of the poor fit of the Gamma distribution to the empirical measures of %VSI to 5% yield. Note, this distribution had the best fit estimate by Crystal Ball; however, this distribution cannot be truncated at 0 %VSI so in combination with the poor fit it was not considered further.

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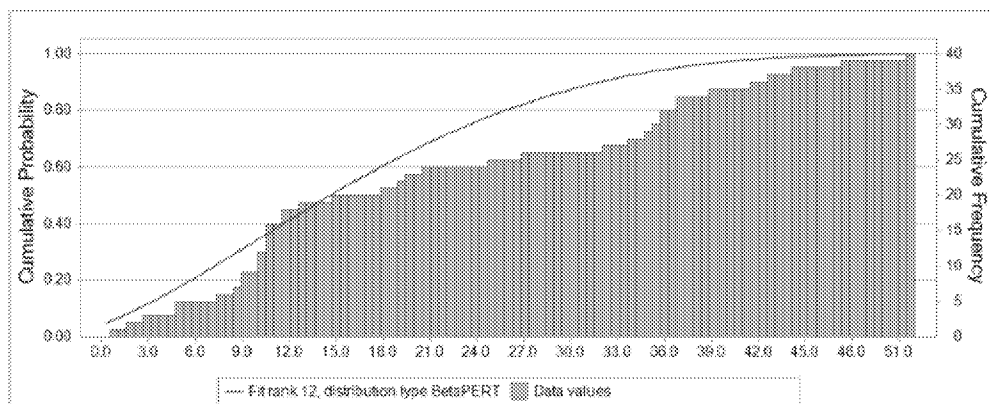
Figure D.7. Illustration of the poor fit of the BetaPERT function to the empirical measures of %VSI to 5% yield.

Table D.3. VSI to Plant Yield Relationships Estimated from the available literature. EPA included studies that measured plant responses following direct spray in field, and from off-site transport of spray drift (D) (Off-Field Movement Studies, OFM).

Study	Exposure	Trial	% VSI at 5% Yield
da Silva	Direct		52.0
da Silva	Direct		11.0
Foster & Griffen	Direct		47.4
Foster & Griffen	Direct		33.7
Growe 2017	Direct	combined	10.1
Growe 2017	Direct	combined	7.6
Growe 2017	Direct	Kingston	8.6
Growe 2017	Direct	Lewiston	12
Growe 2017	Direct	Rocky Mount	12.7
Jones ch1	OFM	1	35.9
Jones ch1	OFM	2	35.5
Jones ch1	OFM	3	32.2
Jones ch1	OFM	4	41.8
Jones ch1	OFM	5	35.8
Jones ch1	OFM	6	10.6
Jones ch1	OFM	7	2.9
Jones ch1	OFM	8	27.2
Jones ch1	OFM	10	44.5
Jones ch1	OFM	11	0.0
Kniss 2018	Direct		18
Kniss 2018	Direct		11
Kniss 2018	Direct		10
Kniss 2018	Direct		12
MRID 50958205	Direct	Tavium Yield MO	43
MRID 50958205	Direct	Tavium Yield MO	37
MRID 50958206	Direct	Tavium Yield MS	15

Study	Exposure	Trial	% VSI at 5% Yield
MRID 50958206	DIrect	Tavium Yield MS	11
MRID 50958206	DIrect	Tavium Yield MS	9
MRID 50958206	DIrect	Tavium Yield MS	5
MRID 51017504	DIrect	Yield MS	37
MRID 51017504	DIrect	Yield MS	39
MRID 51017504	DIrect	Yield MS	21
MRID 51017504	DIrect	Yield MS	19
MRID 51017505	DIrect	Yield IL	10
MRID 51017505	DIrect	Yield IL	9
MRID 51017505	DIrect	Yield IL	2
MRID 51017505	DIrect	Yield IL	5
MRID 51017506	DIrect	Yield MO	25
MRID 51017506	DIrect	Yield MO	35
Robinson 2013	Direct		19.87

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Appendix E. Distance to Effect and Off-field Movement (OFM) Studies

1. Studies Submitted Prior to 2018

Prior to the conditional registration in 2018 that was vacated in 2020, a number of field studies had been submitted to EPA that evaluated the volatility and/or spray drift exposure from field applications of various dicamba products.

1.1. XtendiMax with Vaporgrip

1.1.1. Registrant Submitted Studies

In May and June 2015, field volatility studies were conducted in Chula, GA (MRID 49888501) and Kendleton, TX (MRID 49888503), submitted to EPA in 10/2016 as part of a new product registration application. The test substance used in the field phase of these studies was MON 119096, ax XtendiMax plus Vaporgrip formulation containing dicamba DGA salt (350 g a.e./L). The plot dimensions were approximately 384 feet by 384 feet (3.4 A) in GA and 648 feet by 648 feet (9.6 A) in TX. The test plot at the GA site was a bare ground site treated at a rate of 1 lb a.e./A, while the TX site was a field of cotton, planted with a variety of Bollgard II XtendFlexTM Cotton, treated at a rate of 0.5 lb a.e./A. The cotton was at the 6-8 leaf stage and roughly 11 inches in height, at the time of dicamba application. The boom height for the spray application was set at 14-18 inches above the canopy or ground height. The spray application was made to the GA test plot at 8:00 am on May 5th, while the application to the TX plot was in the afternoon at 1:15 pm on June 8th. In GA temperatures during the first 24 hours ranged from 59-86°F and 60-91°F on Day 2. Relative humidity in GA ranged from 10-94% and soil pH was 6.0. In TX, temperatures during the first 24 hours ranged from 70-98°F and 72-97°F on Day 2. Relative humidity in TX ranged from 18-97% and soil pH was 6.2. The maximum 95th percentile 24-hour average concentrations from air modeling from PERFUM runs performed by the study authors were 20.8 and 8.8 ng/m^3 for the bare and cotton fields, respectively, at the edge of the field. The maximum 90th percentile 24-hour total deposition values from AERMOD runs performed by the study authors were 1.29x10^{-5} and 8.95x10^{-6} lb a.e./A for the bare and cotton fields, respectively, at 5 m from the edge of the field.

In May and June 2015, field volatility studies were conducted in Chula, GA (MRID 49888601) and Kendleton, TX (MRID 49888603), submitted to EPA in 10/2016 as part of a new product registration application. The test substances used in the field phase of these studies were MON 76832, a Roundup Xtend formulation (XtendiMax plus VaporGrip) containing a mixture of dicamba DGA salt (120 g a.e./L) and glyphosate (242 g a.e./L). The plot dimensions were approximately 384 feet by 384 feet (3.4 A) in GA and 648 feet by 648 feet (9.6 A) in TX. The test plot at the GA site was a bare ground site treated at a rate of 1 lb a.e./A, while the TX site was a field of cotton, planted with a variety of Bollgard II XtendFlex Cotton, treated at a rate of 0.5 lb a.e./A. The cotton was at the 6-8 leaf stage and roughly 11 inches in height, at the time of dicamba application. The boom height for the spray application was set at 14-18 inches above the canopy or ground height. The spray application was made to the GA test plot at 9:00 am on May 5th, while the application to the TX plot was in the afternoon at 2:45 pm on June 8th. In GA temperatures during the first 24 hours ranged from 59-86°F and 60-91°F on Day 2. Relative humidity in GA ranged from 10-94% and soil pH was 6.0. In TX, temperatures during the first 24 hours ranged from 70-98°F and 72-97°F on Day 2. Relative humidity in TX ranged from 18-97% and soil pH was 6.2. The maximum 95th percentile 24-hour average concentrations from air modeling from PERFUM runs performed by the study authors were 3.2 and 16.1 ng/m^3 for the bare and cotton fields, respectively, at

the edge of the field. The maximum 90th percentile 24-hour total deposition values from AERMOD runs performed by the study authors were 1.2×10^{-5} and 4.1×10^{-5} lb a.e./A for the bare and cotton fields, respectively, at the edge of the field.

In October 2016, a field volatility study was conducted in Fort Bend, TX (MRID 50578902, submitted to EPA 07/23/2018). The formulation, MON 76980 (which is not registered in the United States but is similar to XtendiMax plus VaporGrip), contains dicamba in the form of its DGA salt (42.8% by weight, 28.9% a.e.). MON 79789, which is glyphosate in the form of its potassium salt (48.7% by weight, 39.6% a.e.), similar to Roundup PowerMAX, was added with MON 76980 to the tank mix. The product was applied at an application rate of 0.5 lb a.e./A on October 4, 2016 at noon to two different types of agricultural field test plots:

1. a fallow (bare ground), 4.6-acre field and,
2. a 9.1-acre field planted with herbicide-tolerant cotton.

The bare ground plot was defined as having stubble less than 7.5 cm (approximately 3 inches) in height in the area of application and measurement. Spray application to the cotton test plot was representative of typical post-emergence herbicide applications to cotton (2-leaf stage or greater at time of application). The boom height for the spray application was set at 50.8 cm (20 inches) above the cotton crop (24-26 inches above the soil surface, indicating the cotton crop was 4-6 inches in height). Temperatures during the first 24 hours ranged from 70-94°F and 72-96°F on Day 2. Relative humidity during application was approximately 57-59%. Soil pH was 5.5 on the bare ground field and 6.8 on the cotton field. The maximum 95th percentile 24-hour average concentrations from air modeling PERFUM runs performed by the study authors were 15.6 and 12.6 ng/m^3 for the bare and cotton fields, respectively, at the edge of the field. The maximum 90th percentile 24-hour total deposition values from AERMOD runs performed by the study authors were 3.68×10^{-5} and 2.9×10^{-5} lb ae/A for the bare and cotton fields, respectively, at the edge of the field. EPA verified the concentration and deposition estimates derived by the study authors.

In December 2017, a field volatility study was conducted in Walgett Shire Australia (MRID 50606801, submitted to EPA 07/23/2018). The test substances used in the field phase of this study were MON 76980 and MON 79789. The formulation MON 76980 contains dicamba DGA salt (29.0% by weight, 28.9% a.e). The formulation MON 79789 contains glyphosate in the form of its potassium salt (39.8% by weight). In addition to the test substances, the tank mix contained Precision Laboratories Intact™ (Lot # PLB-1709-24800-I), a drift control and foliar retention agent and deposition aid, at a rate of 0.5% v/v. Intact™ contains polyethylene glycol, choline chloride, and guar gum as principal functioning agents that comprise 43.18% of the product. The plot dimensions were approximately 1280 feet in length and 1260 feet in width, for a total treated area of approximately 37 acres. The test plot and surrounding buffer zone was planted in a glyphosate, but not dicamba, tolerant variety of soybean. Soybean plants were roughly 6 inches in height. The boom height for the application was set at 24 inches above the soybean crop. The spray application was made to the test plot at 10:30 am on December 15, 2017. MON 76980 was applied at a target rate of 22 oz/A (0.5 lb a.e./A) and MON 79789 was applied at a target rate of 32 oz/A (1.125 lb a.i./A). Temperatures during the first 24 hours ranged from 76-106°F and 77-106°F on Day 2. Relative humidity during application was approximately 32%. Soil pH was 7.6. The maximum 95th percentile 24-hour average concentration from air modeling from PERFUM runs performed by the study authors was 4.4 ng/m^3 for the soybean field at the edge of the field. The maximum 90th percentile 24-hour total deposition value from AERMOD runs performed by the study authors was 2.68×10^{-5} lb a.e./A for the soybean field at the edge of the field. EPA verified the concentration and deposition estimates

derived by the study authors. It should be noted that EPA classifies this study as supplemental because flux rates for Day 2 could not be calculated due to high wind conditions. Originally the study included plant effects measurements in an attempt to differentiate plant injury due to spray drift versus volatility. However, prior to study initiation, the study area and the surrounding area were damaged by 2,4-D spray drift. Additionally, residual isoxaflutole was measured in the soil, confounding plant damage measurements. As a result, an assessment of plant damage surrounding the treated area was not included in the study.

In May 2018, a field volatility study was conducted in Maricopa, AZ (MRID 50642801, submitted to EPA 08/23/2018). Approximately 27 acres (1050 ft in length and 1120 ft wide), in the center of a 33-acre agricultural field planted with non-tolerant soybean, was treated with XtendiMax with VaporGrip, RoundUp PowerMAX, and Intact, on May 8, 2018 at 4:15 pm. The test plot and surrounding buffer zone were planted in non-tolerant soybean on April 3, 2018. Test substance applications were made using a John Deere 4630 ground sprayer equipped with an 80 ft boom and Turbo TeeJet Induction (TTI) 11004 nozzles. A spray drift test system consisted of three downwind transects (east side of field) spaced approximately 15 m apart perpendicular to the spray area near the middle of the spray swaths. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all three transects at 5, 10, 15, 20, 25, and 30 m away from the field. Deposition collectors were mounted on metal posts elevated to the soybean crop height (15 cm). Three upwind (west side of field) collectors were located along the depositional transects 30 m from the upwind edge of the spray area, and three were located 40 m from the upwind edge of the spray area. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented upwind and downwind of the treated areas. Plant effect transects were planted perpendicular to the eastern (downwind) and western (upwind) edge of the applied area to a maximum distance of 30 m (3 downwind pairs and 2 upwind pairs) to evaluate volatility and spray drift exposure. Plant effects from volatility were evaluated by covering approximately 30 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were removed approximately 30 minutes after application. Plants were measured before application (five sets of ten plants) from downwind, upwind and within the designated treated area to better characterize the inherent variability across the field. Control (untreated/no visual dicamba injury observed) plant height measurements (ten sets of ten plants) were collected non-systematically from areas further upwind of the upwind transects on the same day as plant height assessments. At each study transect, plant heights were measured 15 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (5, 10, 15, 20, 25 and 30 m).

The wind directions at the time of application were variable within and outside of the target, with an orientation of 267°. Wind directions and wind speeds during the daytime (8:00 am to 8 pm) and nighttime during conduct of the study are provided in **Figures E.1** and **E.2**. Temperatures for three days after application ranged from 18.5 to 40.4°C (65 to 105°F) and relative humidity ranged from 8.3 to 38.9%. Flux rates were estimated using the integrated horizontal flux technique, the aerodynamic method, and the indirect method. On-field wind speed samplers malfunctioned during the first 27 hours of sampling, so study authors attempted to relate the wind speeds from an off-field meteorological station to the wind speeds that would be expected at the on-field samplers. While the flux rates estimated using the integrated horizontal flux method and the aerodynamic flux method, which used these estimated wind speeds, during this time were not significantly different than those estimated using the indirect method, the flux rates using the indirect method were higher and were considered

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more protective. These were the flux rates used in the air modeling as well, which yielded a maximum 95th percentile 24-hour average concentrations from PERFUM runs performed by the study author of 3.6 ng/m^3 for the soybean field at the edge of the field and a maximum 90th percentile 24-hour total deposition value from AERMOD runs performed by the study author of 1.00×10^{-6} lb a.e./A for the soybean field at the edge of the field. EPA verified the concentration and deposition estimates derived by the study authors.

Spray drift measurements indicated that dicamba residues were not detected in any of the upwind samples and were detected at levels below 24.5 µg/m^2 (2.19×10^{-4} lb/A). It should be noted that wind directions at the time of application were variable within and outside the target orientation of 267°. Additionally, samples were collected 3 minutes after applications were complete, which may not have been sufficient time for airborne droplets to deposit. As such, deposition values are considered uncertain.
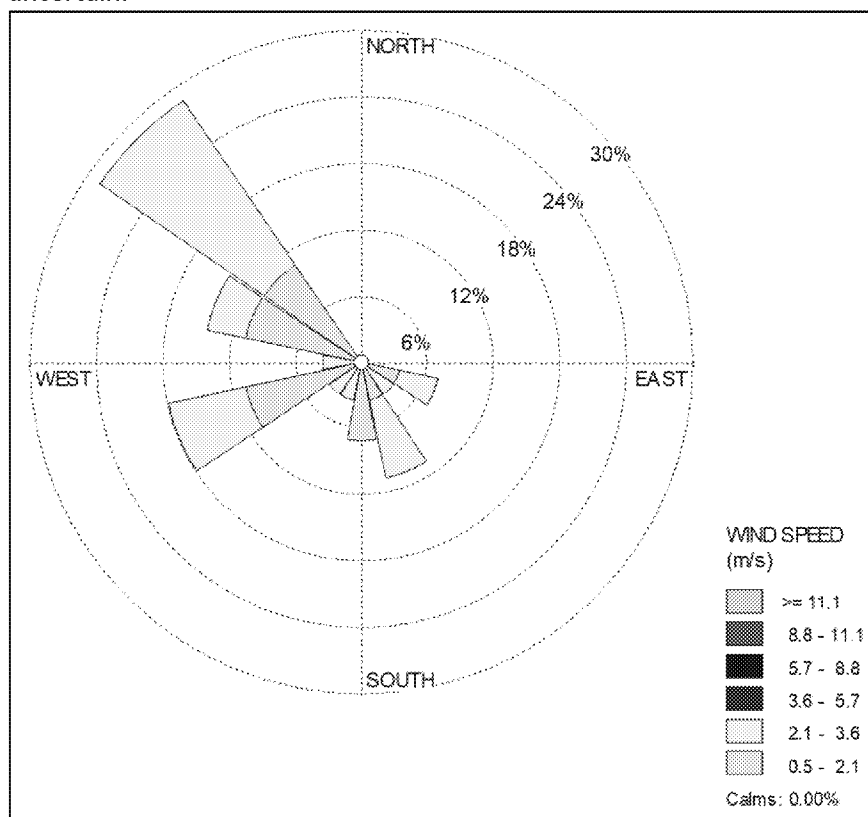
Figure E.1. Wind Rose Plot, AZ Study, Daytime Hours (direction from which wind was blowing)
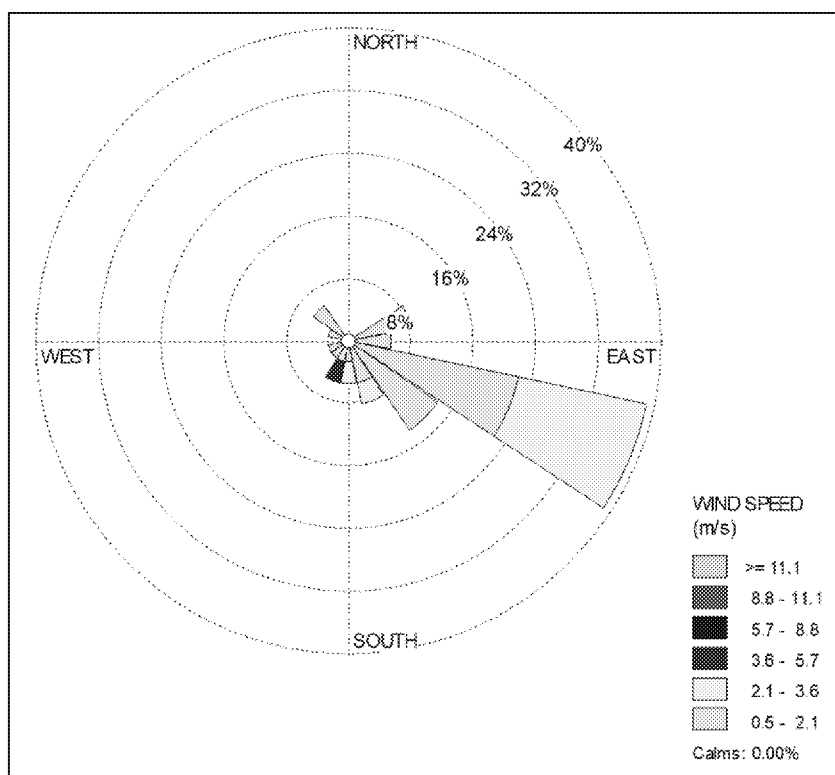
Figure E.2. Wind Rose Plot, AZ Study, Nightime Hours (direction from which wind was blowing)

At 28 DAT, no visual symptomology was reported in the downwind and upwind volatility transects off the treated field. Visual symptomology in the downwind spray drift transects was more pronounced compared to the downwind volatility transects. Visual symptomology in the spray drift transects decreased with increased distance from the treated area ranging from 30% at 5 m to a maximum of 5% at 30 m. Following 28 DAT, significant differences on plant height were observed between the downwind spray drift and volatility transects at 15 and 30 m; however, the differences were not considered treatment related as there was no clear dose response with respect to plant heights (**Figure E.3**). For example, plant heights were significantly greater in the volatility transects at 15 m, whereas at 30 m plants were larger in the drift transects. Although attempts were taken to minimize variability, plant height differed across the field from the upwind to the downwind area (at Day 0, the average upwind plant height was 9.3 cm and the average downwind plant height was 7.64 cm). Therefore, due to the nonuniformity of plant height across the field, study authors did not perform a comparison of the plant height data to the upwind controls.

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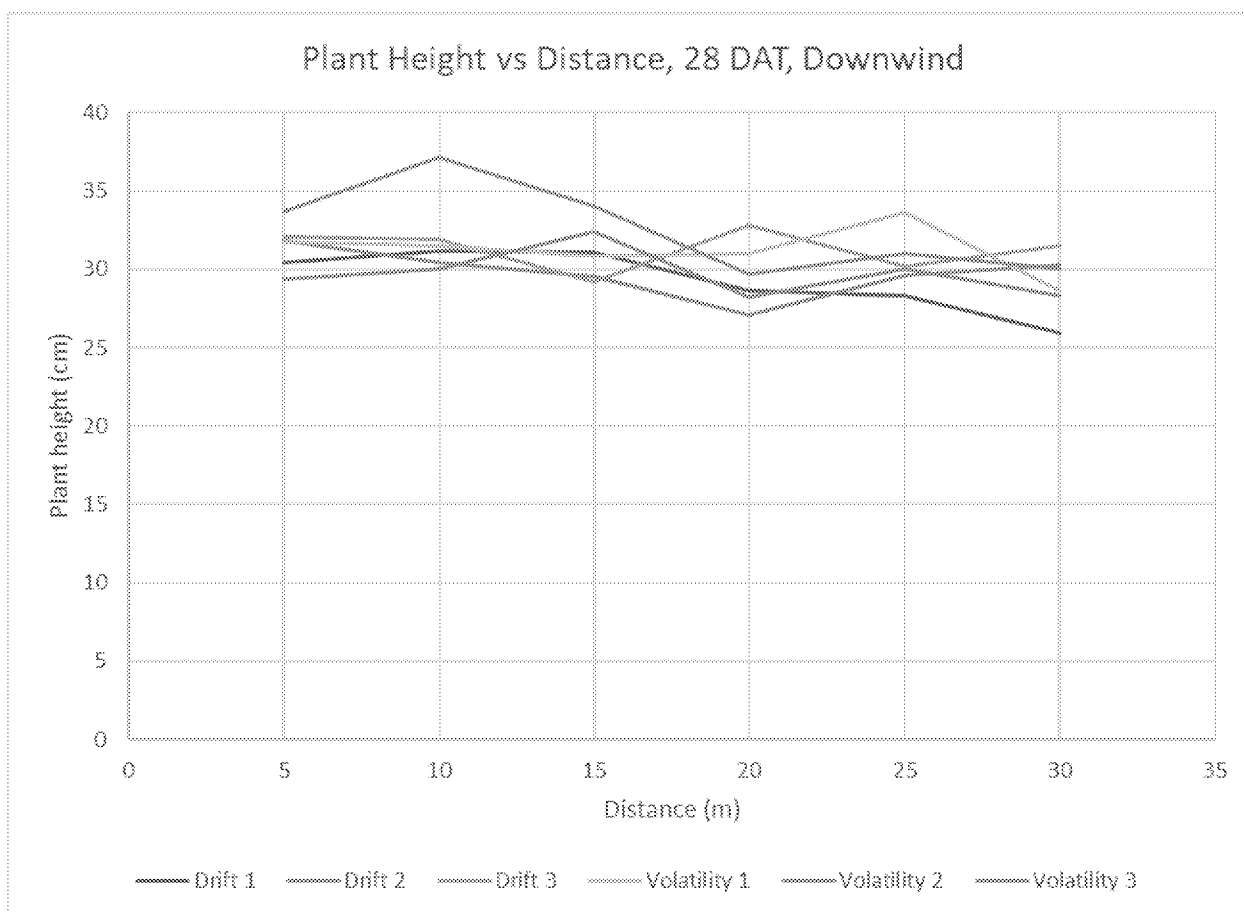
Figure E.3. Plant Height Comparison, AZ Study

1.1.2. Academic Studies

1.1.2.1. 2017 Field Studies

In 2017, a series of small-scale field studies (0.17 – 3.5 acres) were conducted in Nebraska, Indiana, Arkansas, Tennessee, and Missouri. Studies looked at plant effects (visual injury and plant height) to spray drift and volatility to soybean plants in the downwind direction from a field treated with XtendiMax or Engenia (Norsworthy 2018c). A summary of the field conditions is provided in **Table E**.1. Based on an analysis of the visual injury reported versus distance for each trial, the distance to 10% visual injury is provided in **Table E.2**. It should be noted that the trial conducted in Nebraska may have been compromised, as an application occurred to a nearby field that may have impacted the results.

Plant height data were only available for the Arkansas field trial. Height measurements for control plants were not provided, so the average height of the plants at the last three distances (85, 91, and 97 m) were used as a surrogate for controls to evaluate plant height effects with distance. For the Arkansas field trial, at 25 DAT, height effects were not significantly different across the transects or among them for the trial conducted using XtendiMax. For the trial conducted using Engenia, height effects were significantly different when comparing 3 to 9 m distances to the 60+ m distances.

It should be noted that meteorological data for the duration of the study trials were not provided, so it is uncertain if the wind blew the majority of the time in the direction of the soybean plants that were analyzed. Completion of a review for these studies will require additional information, in the form of a study report, and a better understanding of the nature of the field trials.

Table E.1. Study Conditions, 2017 Small Scale Trials

Application Info	NE	IN	AR	TN	MO
Study Conductor	Kruger	Young	Norsworthy	Steckel	Bradley
Application date	7/6/2017	8/27/2017	7/20/2017	7/27/2017	7/20/2017
Start time	11:00 AM	3:04 PM	11:56 AM	10:45 AM	11:00 AM
Stop time	11:19 AM	3:19 PM	12:19 PM	10:52 AM	11:20 AM
Avg. air temp during application (F)	88	79	94.2	84.2	88.9
Max. air temp day of application (F)	100.7	82.3	96.4	91.5	94.9
Relative humidity during application (%)	46.3	47	59.4	84	60
Avg. wind speed during application (mph)	5.25	4.2	2.9	3.3	5.3
Wind direction during application (degrees)	250	80	259	225	240

Table E.2. Summary of Distances (meters) to 10% Injury for Primary and Secondary Exposures

Product	Exposures	Distance (m)				
		NE	IN	AR	TN	MO
XtendiMax with Vaporgrip	Primary and Secondary Exposure	70	<10	55	18	41
XtendiMax with Vaporgrip	Secondary Exposure only	60	<10	40	10	15
Engenia	Primary and Secondary Exposure	60	<10	40	28	28
Engenia	Secondary Exposure only	60	<10	25	10	10

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1.1.2.2. 2018 Field Studies

1.1.2.2.1. Jones 2018

Jones (2018) presents additional lines of evidence related to non-target plant effects from off-site drift that were not available from earlier data sets. The study provides data on the extent of plant growth and yield measures with distance from the treated site rather than relying solely on metrics such as VSI. The study also provides evidence on the combined spray and volatile drift mediated effects (visual injury, growth, and yield) as well as the proportional contribution of primary spray drift and secondary volatile drift to overall plant injury. The combined route of exposure is a line of evidence different from the previous effects determinations where effects associated with volatile and spray droplet drift were quantified separately rather than in combination. For trials involving primary (spray drift) and secondary drift (vapor drift), plant injury was higher for plants exposed to primary and secondary drift, than those exposed only to secondary drift. The study of the differential effect of spray versus volatile drift did not include measurements of plant height or pod development or yield so the proportion of such effects that would be attributable to each exposure route or the combination of these exposure routes cannot be determined. EPA limited the analysis of the study results to the BAPMA product, as the DGA product used in the study, Clarity, is not registered for over-the-top use on soybeans. As such, EPA did not further evaluate the estimates derived for primary and secondary drift.

1.1.2.2.2. Large-scale Academic Field Trials

A series of field trials were designed to evaluate off-target movement via spray drift and volatility when applied to large areas (10 – 40 acres). Applications were made under conditions consistent with the current XtendiMax with Vaporgrip label. Tank mixtures of XtendiMax with Vaporgrip plus PowerMAX plus Intact were applied consistent with labeled requirements for nozzles and wind speed restrictions. Off-target movement was assessed via air samplers, horizontal mylar sample collectors, and a bio-indicator crop of non-DT soybean. These large-scale trials were conducted by the University of Arkansas, University of Wisconsin-Madison, Purdue University, Michigan State University, and the University of Nebraska.

Treated areas were planted with Roundup Xtend DT soybeans while the surrounding area was planted with a non-DT soybean of a similar maturity group. Applications are designed to target the largest soybean possible before reaching a flowering stage (~V5-V6). The treated areas were surrounded by non-DT soybean, such that samples could be taken for a minimum of 300 feet (91 m). Sample stations were located at various distances (4, 8, 16, 30.5, 45, 60, 75, 90, 105, 120 m) downwind of the application, determined by the available site-specific wind direction at the time of the study. Residues from sample collectors were sent to the University of Nebraska for analysis. To assess volatility, polyurethane foam (PUF) samples were collected and placed in uniquely labeled containers, to be analyzed by the Mississippi Department of Agriculture State Chemical Laboratory. The PUFs were collected approximately 6, 12, 24, 36, 48, 60, and 72 hours following completion of the application to the entire plot.

Spray drift impacts on non-DT soybean were assessed by comparing plant heights and visual plant response along transects perpendicular to the edges of the field to a distance of 100 m. Plant effects from vapor drift were assessed by covering a portion of the non-DT soybean crop during the application

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period to prevent exposure to spray drift. The cover was removed post-application. Plant heights were measured approximately 14- and 21-days post-application on ten plants at each distance along each transect. Control (untreated) plants were measured just prior to the application at each site as a measure of inherent variability in the plant sizes across the field. In addition, upwind plant height measurements were taken on the day assessments were made. These measurements were taken at least 50 to 100 m upwind of the "upwind edge" of each sprayed area and in areas where visual dicamba symptomology was not expected.

Visual plant response was assessed on a scale of 0 to 100 with 0 representing no visible plant response and 100 representing complete plant death. This plant response rating scale was conducted consistent with visual plant response ratings described in Frans (Frans, 1977), Behrens and Lueschen (Behrens, 1979), and Sciumbato et al. (Sciumbato et al., 2004). For selected plots and timings, photographs were made to document the visual plant response symptoms, and severity at specified distances.

University of Arkansas

In 2018, Dr. Norsworthy from the University of Arkansas provided results for the field trial conducted in Arkansas, where a 38.5-acre field of DT soybean inside of a larger 240-acre field of non- DT soybean was treated on 7/16/18 at 3 pm (Norsworthy 2018a). Wind speed during the application varied from 1 mph to 6 mph, with wind direction varying from winds from the west (start) to winds out of the south (completion). As prevailing winds were described as coming from west to east, only one transect was used on the north and south sides of the field. However, based on the wind measurements during the first three days, the majority of the winds were from the south (**Figure E.4**). The wind direction profile for the daytime (8 am to 8 pm) hours was consistent with the profile during the nighttime hours (8 pm to 8 am). It should be noted that for 7 days prior to the application, no sustained wind speeds above 3 mph (minimum wind speed limit on the label) were observed. In an effort to apply the XtendiMax before the R2 growth stage occurred (XtendiMax with Vaporgrip only allows applications up to the R1 growth stage), the application was made on July 16th. Winds after application continued to be low, with the majority of the wind speeds in the range of 0.5 to 2.1 m/s (1 to 5 mph). Buckets were placed on plants every 50 ft, and a 12 x 25 ft^2 tarp was placed on top of soybean plants outside the field to evaluate the impacts of secondary only drift. Temperatures ranged from 75 to 92°F. Relative humidity data during the course of the study were not provided. Twenty-two days after treatment, visual injury was similar for plants exposed to primary spray and secondary volatility drift and those exposed to secondary drift alone. Twenty percent visual injury occurred out to a distance of 200-250 ft (61-76 m). Twenty-nine days after treatment, 20% visual injury due to drift (it was not specified whether the damage was due to primary or secondary drift) was reported along the east and south sides of the field at approximately 150 ft (46 m) and between 200 and 250 ft (61-76 m) along the west side. Forty percent visual damage along the north side of the field extended beyond 750 ft (229 m) but was attributed to runoff from flood irrigation. Plant height measurements along the transects were made at 15 and 22 DAT. There were no significant differences between the height of plants on the upwind and downwind sides of the treated field or with distance away from the field. Flux rates for the study ranged from 1.46x10^{-4} to 7.68x10^{-4} μg/m^2-s.

Several deviations from the protocol above were noted. UR110-10 nozzles were used instead of the TTI 11004. The UR110-10 are permissible according to the XtendiMax with Vaporgrip label. The tank mix was held for 7 days, so there is the potential that the products were not thoroughly mixed or could have degraded. Lastly, the product Warrant (a microencapsulation of acetochlor) was also added to the tank mix. The label for Warrant indicates that the product should be used immediately and not in irrigation.

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EPA questioned whether any plant damage resulting from use of acetochlor could be differentiated from damage due to dicamba. Subsequent discussions with (Norsworthy, 2018b) and information provided by Dr. Norsworthy indicated that the tank mix containing Warrant had no undue effects on the study results and that damage resulting from acetochlor was easily distinguishable from that caused by dicamba. Additionally, there was no acetochlor damage to the DT soybeans or the non-DT soybeans surrounding the treated area.
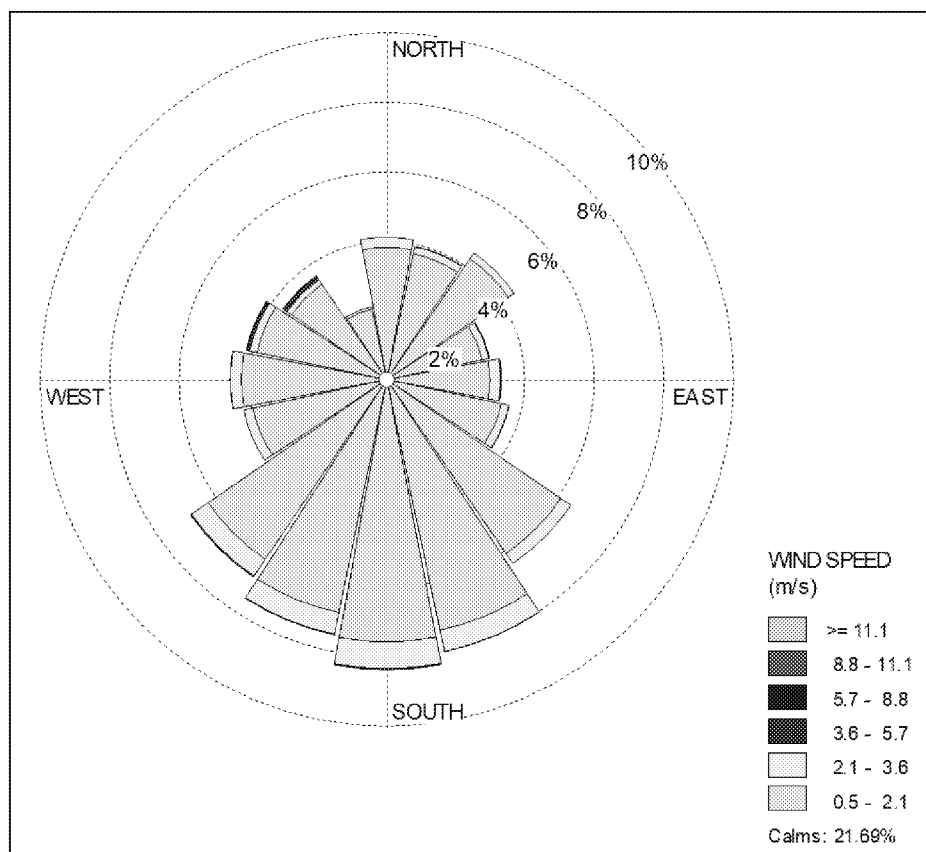
Figure E.4. Wind Rose Plot, Norsworthy Study (direction from which wind was blowing)

University of Wisconsin-Madison

Also, in 2018, Dr. Werle from the University of Wisconsin-Madison also submitted data in support of the large field study effort. An 8-acre plot of soybeans at the V5 stage was treated on 7/11/18 with XtendiMax with Vaporgrip plus PowerMAX (Werle, 2018). The air temperature during the application was 81°F, while the soil temperature was 75°F. Winds during the application were out of the southeast at 3-6 mph. Temperature during the first 19 days of the study ranged from 49 to 90°F and relative humidity ranged from 42 to 100%. Inversion conditions appeared to occur during the evenings during the course of the study. Soybean was at the V5/V6 growth stage and was 13 inches tall. Three transects along the north side of the field and one transect along the south side were assessed for soybean injury. Along the north transects, 20% visual injury was reported out to about the 6th-9th row of soybeans at 14 DAT (**Figure E.5**) and the 6th-14th row of soybeans at 28 DAT (**Figure E.6**). At both times, visual damage for the uncovered plants tended to be higher than those that were covered, indicating that primary and secondary drift played more of a role in the visual damage than secondary drift alone. Each row was

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approximately 30 inches in width, so the distance would be, at a minimum, 15-23 ft (5-7 m) at 14 DAT and 15-35 ft (5-11 m) at 28 DAT. The south side did not indicate any visual injury to plants. However, it should be noted that winds didn't blow from the north and blew from the northwest and northeast approximately 22% of the time (**Figure E.7**), so it is uncertain if the plants along the single south transect were exposed. Plant height measurements along the transects were made at 14 and 28 DAT. There were no significant differences between the height of plants on the upwind (south) and downwind (north) sides of the treated field or with distance away from the field. Flux rates for the study ranged from 1.10×10^{-4} to 5.75×10^{-4} $\mu g/m^2$-s.
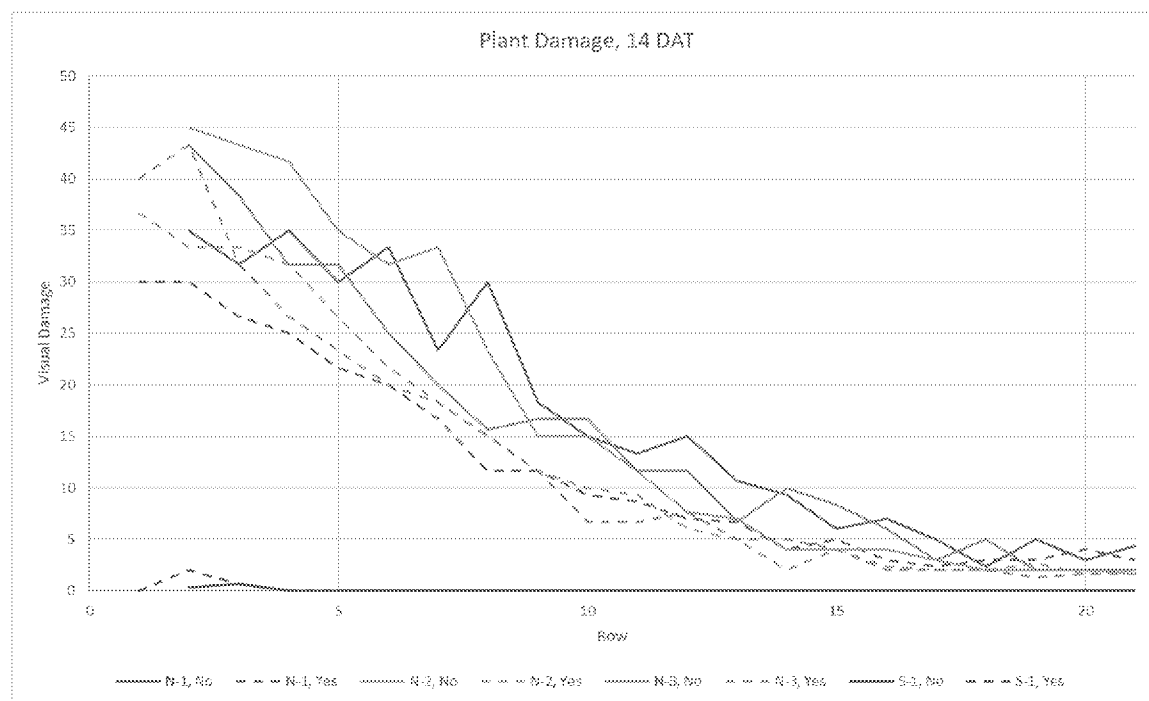
Figure E.5. Plant Damage at 14 Days After Treatment, Werle Study
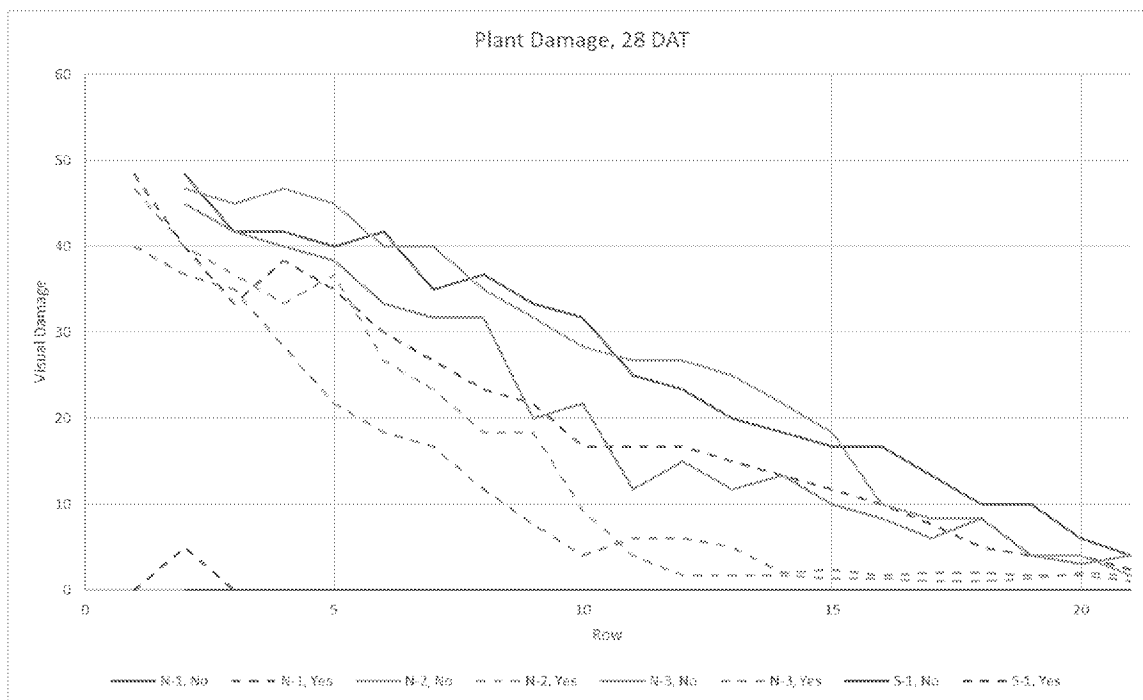
Figure E.6. Plant Damage at 28 Days After Treatment, Werle Study
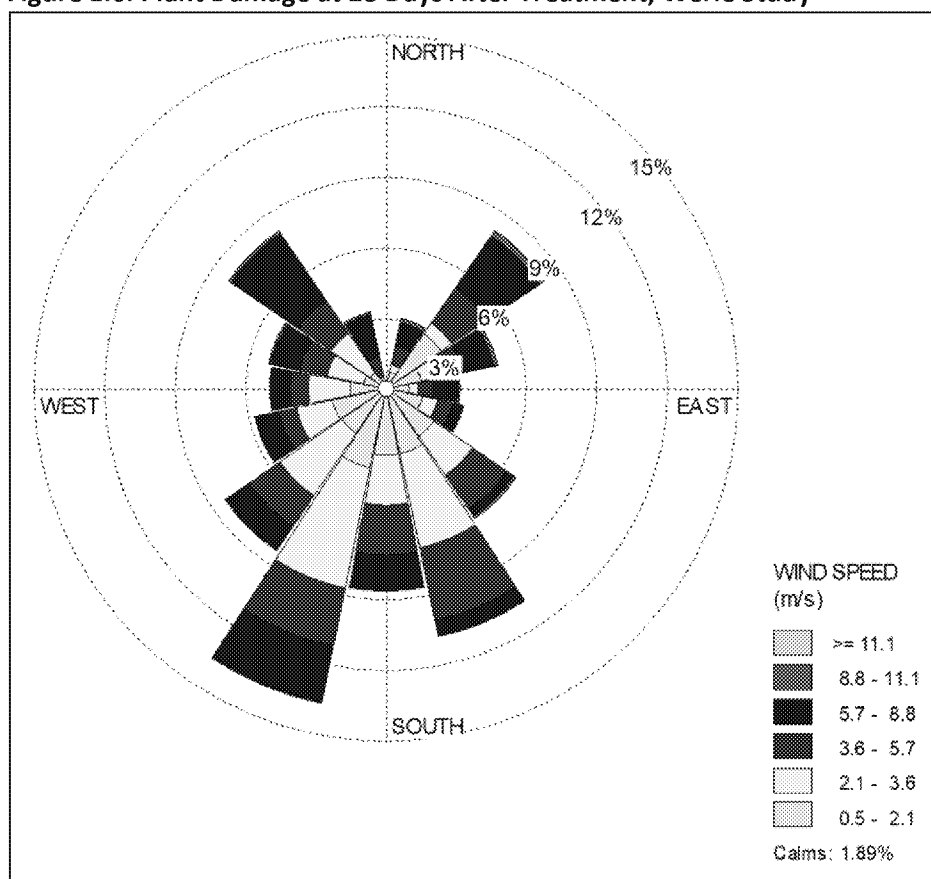
Figure E.7. Wind Rose Plot, Werle Study (direction from which wind was blowing)

In 2018, Dr. Young from Purdue University also submitted data in support of the large field study effort. A 20-acre plot (1000 ft x 2800 ft) of DT soybeans surrounded by 44 acres of non-DT soybeans at the R1 stage was treated on 8/9/18 with XtendiMax with Vaporgrip plus PowerMAX (Young 2018a). The air temperature during the application was 84°F and relative humidity was 64%. Winds during the application were out of the southwest at 1.5-7 mph. Temperature during the first 19 days of the study ranged from 53 to 88°F and relative humidity ranged from 48 to 100%. Inversion conditions appeared to occur during the evenings during the course of the study; in many cases the wind speeds during the inversions were recorded as 0 mph. Three transects along the east side of the field and one transect along the west side were assessed for soybean injury. Three separate transects, 8 ft x 50 ft, along the east side were covered by tarps to evaluate secondary volatility drift only. A series of controls were also assessed for primary (spray drift) and secondary (volatility) drift but is unclear where these transects were located. Along the east transects, 20% visual injury was reported out to about the 15-20 ft at 14 DAT (**Figure E.8**) and the 0-22 ft at 21 DAT (**Figure E.9**). At both times, visual damage for the uncovered plants were higher than those that were covered, indicating that primary and secondary drift played more of a role in the visual damage than secondary drift alone. Covered plants did not show visual damage above 10%. Control plants showed significant visual damage inside of 15 ft at both 14 and 21 DAT, but showed similar visual damage to the plants along the east transects beyond 15 ft. The west side did not indicate any visual injury to plants. However, it should be noted that winds only blew out of the west 14% of the time and from the east 6% of the time (**Figure E.11**), so it is uncertain how much exposure the plants along the east and west transects received. Plant height measurements along the transects were also made at 14 and 21 DAT. There were no significant differences between the height of plants on the upwind (west) and downwind (east) sides of the treated field or with distance away from the field. However, on the east side of the field, covered plants heights were lower than those plants that were uncovered (**Figure E.10**). By 21 DAT, covered and uncovered plant heights were similar. Additionally, control plants showed significant plant height reduction at distances up to 10 ft, at which point the plant heights in the controls were the same as those in the east and west transects. Flux rates for the study ranged from 1.84×10^{-9} to 4.26×10^{-4} µg/m^2-s.

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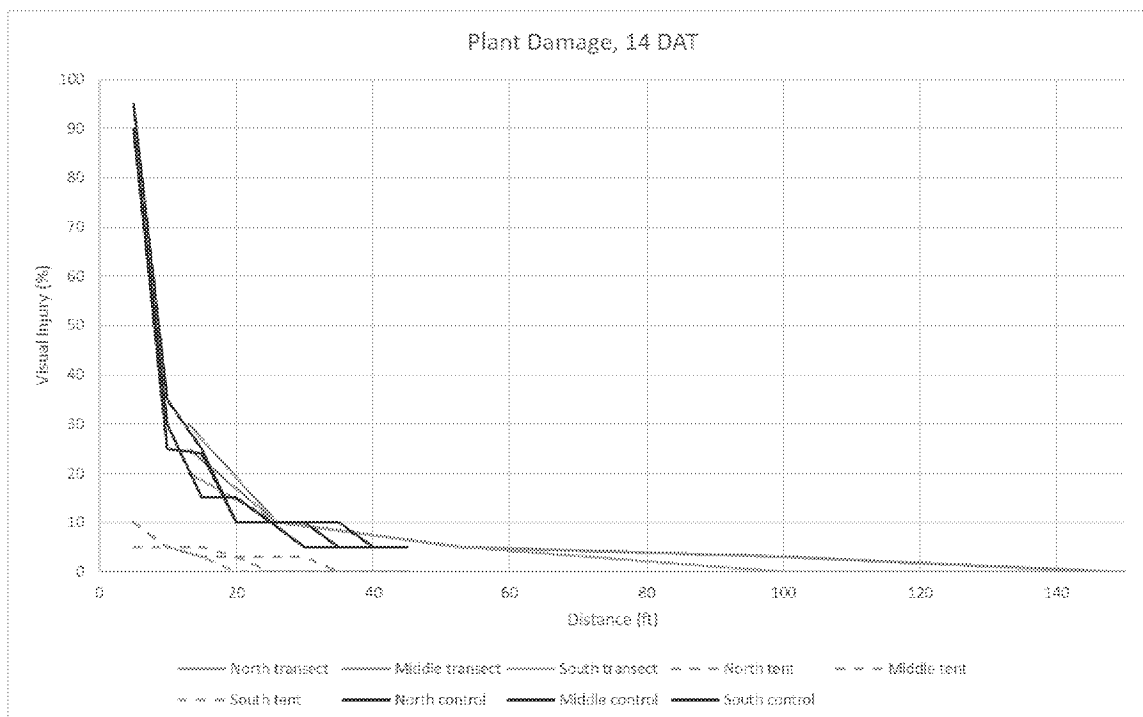
Figure E.8. Plant Damage at 14 Days After Treatment, Young Study
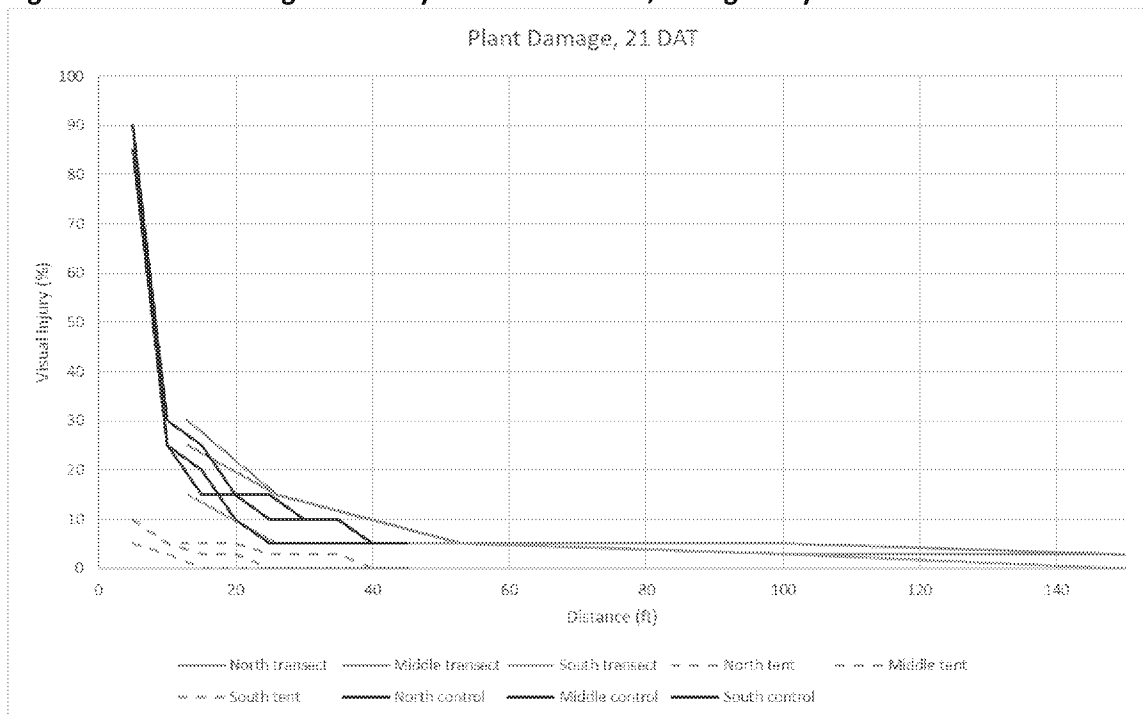
Figure E.9. Plant Damage at 21 Days After Treatment, Young Study

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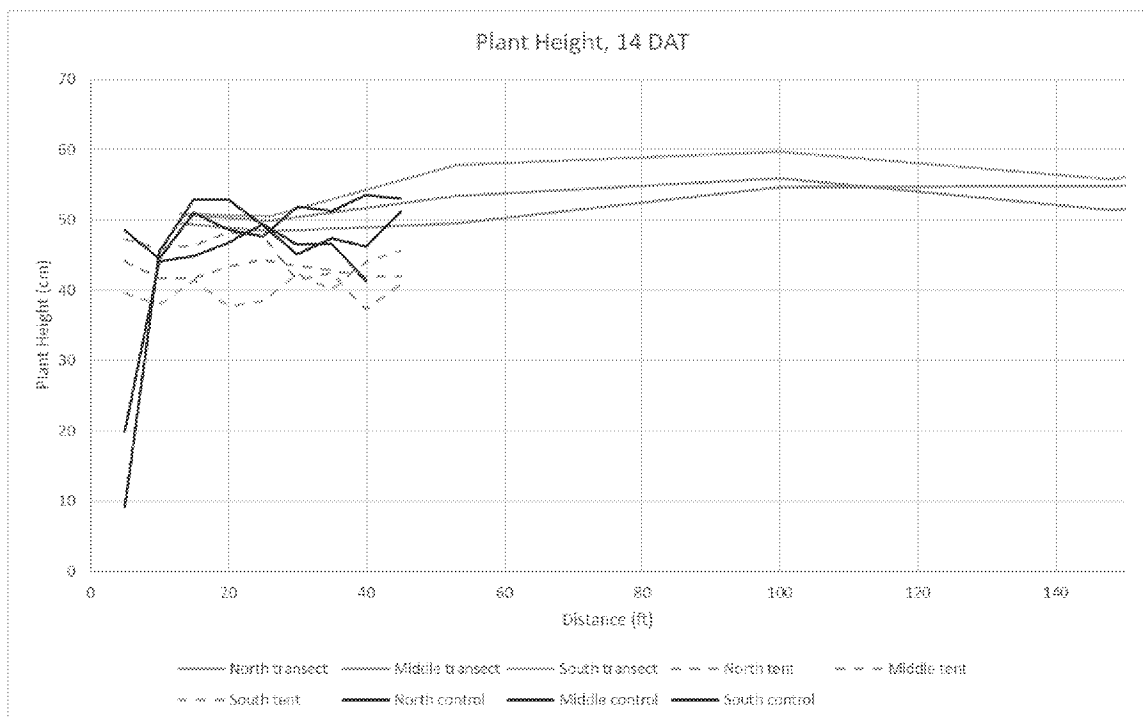
Figure E.10. Plant Height 14 Days After Treatment, Young Study
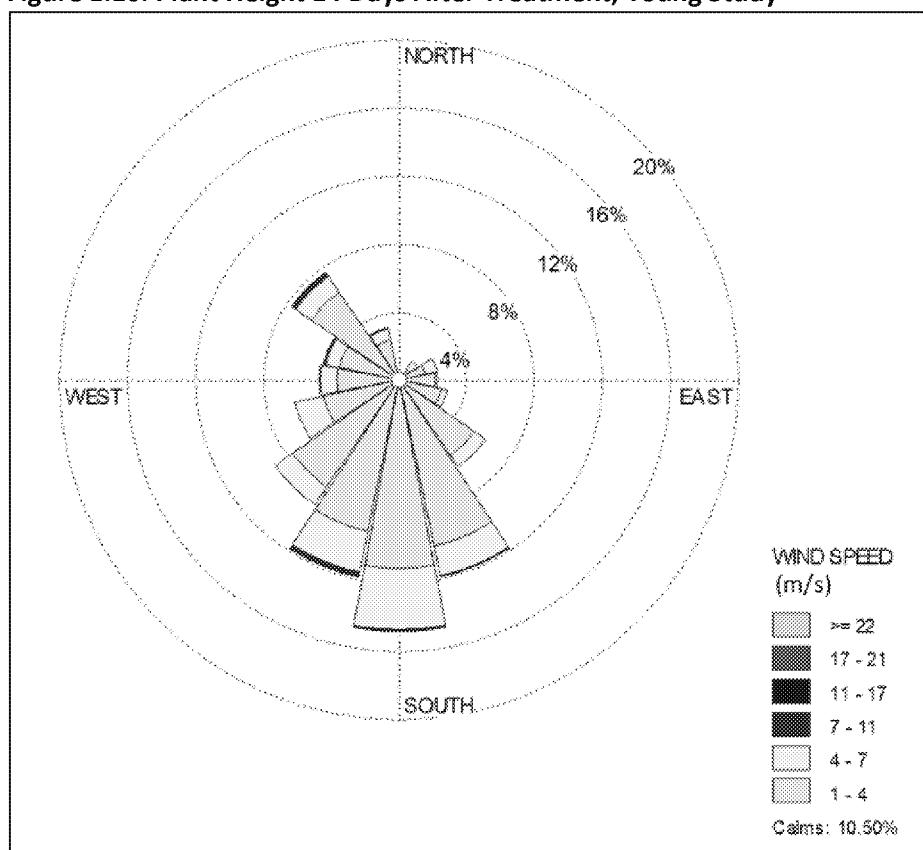
Figure E.11. Wind Rose Plot, Young Study (direction from which wind was blowing)

In 2018, Dr. Sprague from the Michigan State University submitted data in support of the large field study effort. A 53-acre plot of a 300-acre field was planted with DT soybeans surrounded by non-DT soybeans on May 4-6, 2018. Xtend soybeans were treated at the V3 stage on 6/12/18 with XtendiMax with Vaporgrip plus PowerMAX between 10 and 11 am (Sprague 2018). The air temperature during the application was 71°F and relative humidity was 78%. Winds during the application were out of the east to southeast at 3-7 mph. Temperature during the first 9 days of the study ranged from 53 to 93°F and relative humidity ranged from 25 to 99%. It should be noted that air temperatures only exceeded 90°F for two short periods (4 hours) 5 and 6 days after application. It is uncertain if inversion conditions occurred during the study as temperature at different heights was not available. Winds were primarily out of the northeast and southwest during the study (**Figure E.12**). Two transects 120 m in length along the north side of the field (Transects B and C) and one transect along the west side (Transect A), near the northwest corner of the field, were assessed for soybean injury. Tarped regions, 12 ft x 50 ft, near the three transects in the north and west, were covered to evaluate secondary drift only. A series of untarped and tarped upwind areas, 8 to 30 m from the field, were also assessed for primary and secondary drift. Two of the transects, one in the north and the west transect, showed signs of visual injury, with distances to 20% visual injury reported out to about the 13-26 ft (4-8 m) at 14 DAT (**Figure E.13**) and the 26-52 ft (8-16 m) at 21 DAT (**Figure E.14**). At both times, tarped plants exhibited no signs of visual damage at 14 DAT and < 20% damage at 21 DAT for the entire 50 ft distance, indicating that primary drift played more of a role in the visual damage than secondary drift alone. Plant height measurements along the transects were also made at 14 and 21 DAT. Plants along Transect A appeared to show signs of reduced height up to approximately 25 ft from the edge of the field at 14 and 21 DAT; transects to the north did not appear to show signs of plant height reductions except at a distance of between 246 to 344 ft away where study authors noted a low area that appeared affected (**Figure E.15** and **Figure E.16**). Upwind plants showed 20% visual injury at distances less than 2.5 ft from field at 21 DAT. While deposition data were measured, measurement values were not provided to EPA to understand the spray drift deposition pattern. Flux rates for the study ranged from 1.61×10^{-6} to 6.80×10^{-4} $\mu g/m^2$-s. Although EPA was unable to estimate plant height reduction using regressions, visual interpretation puts 21-DAT 5% height inhibition, relative to controls, at approximately 10 meters for Transect A. Substantial variability was observed across the other two transects. 21-DAT 10% visual injury, relative to controls, was observed out to approximately 25 meters in two transects, but only 5 meters in the third.
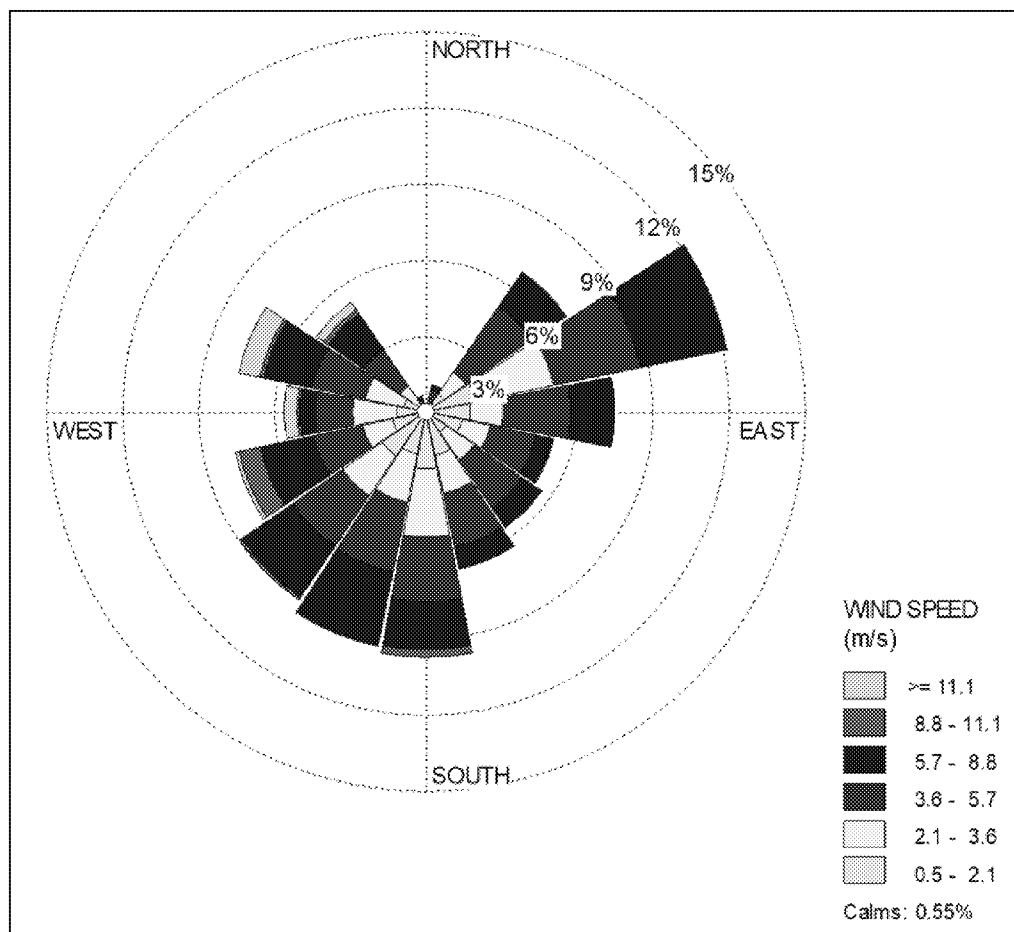
Figure E.12. Wind Rose Plot, Sprague Study (direction from which wind was blowing)
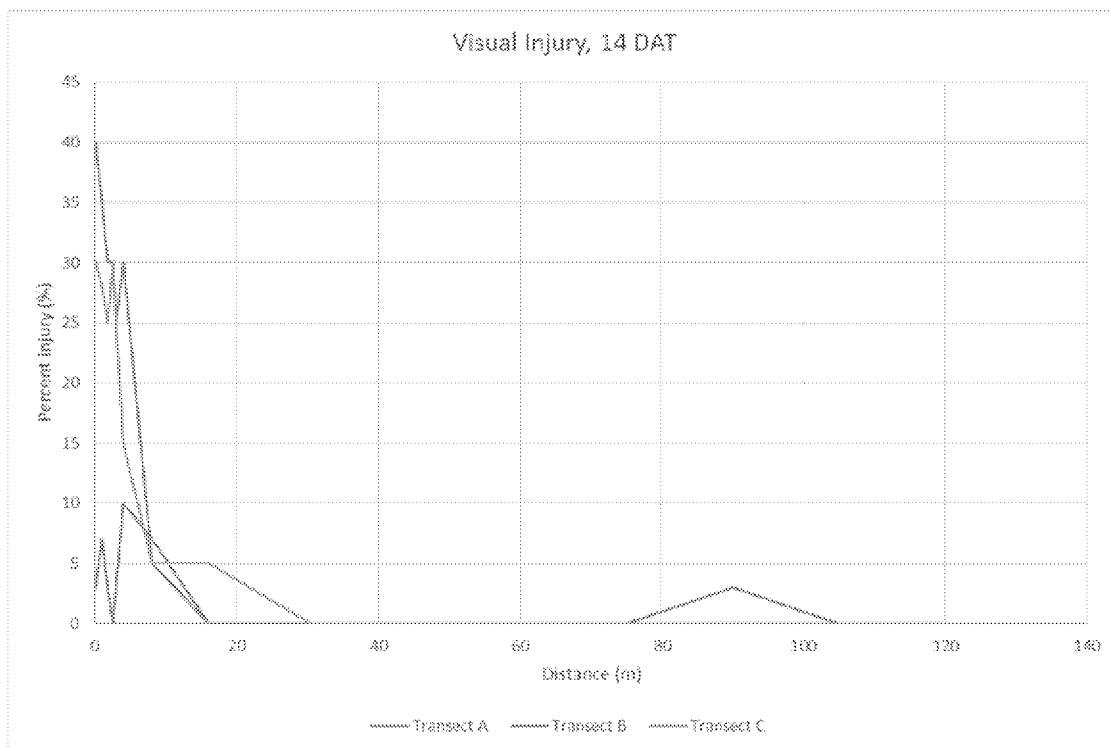
Figure E.13. Visual damage, 14 DAT, Sprague Study
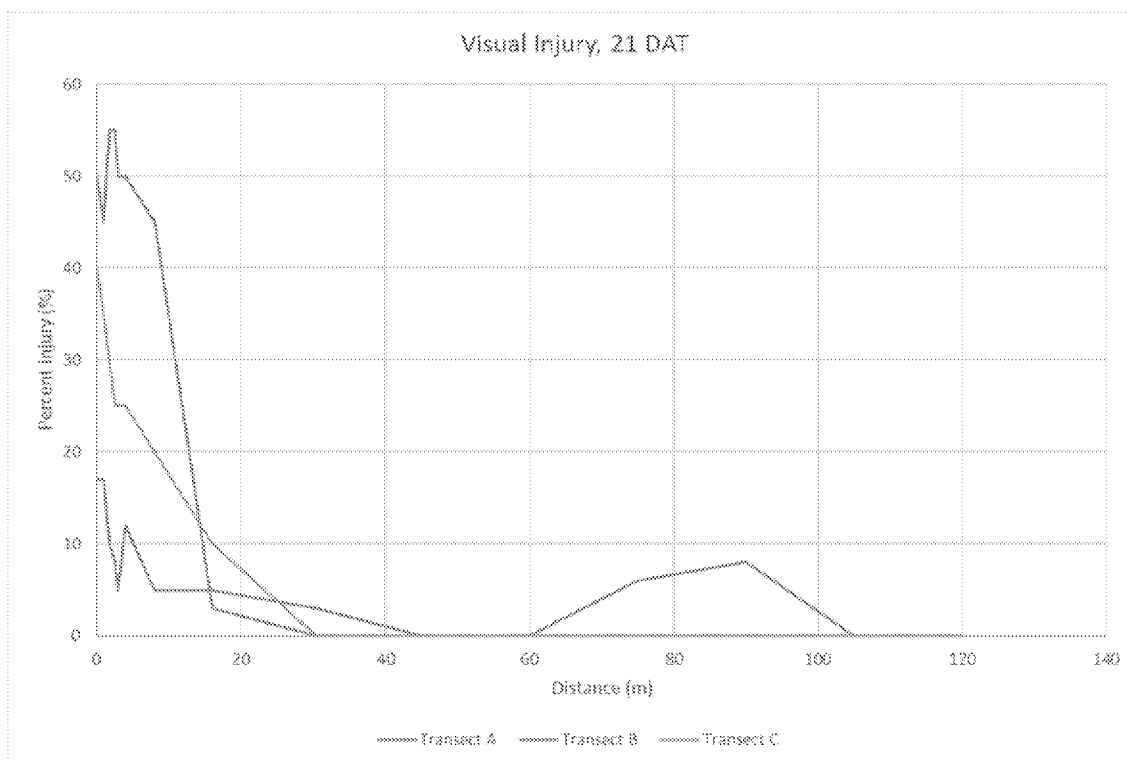
Figure E.14. Visual Damage, 21 DAT, Sprague Study
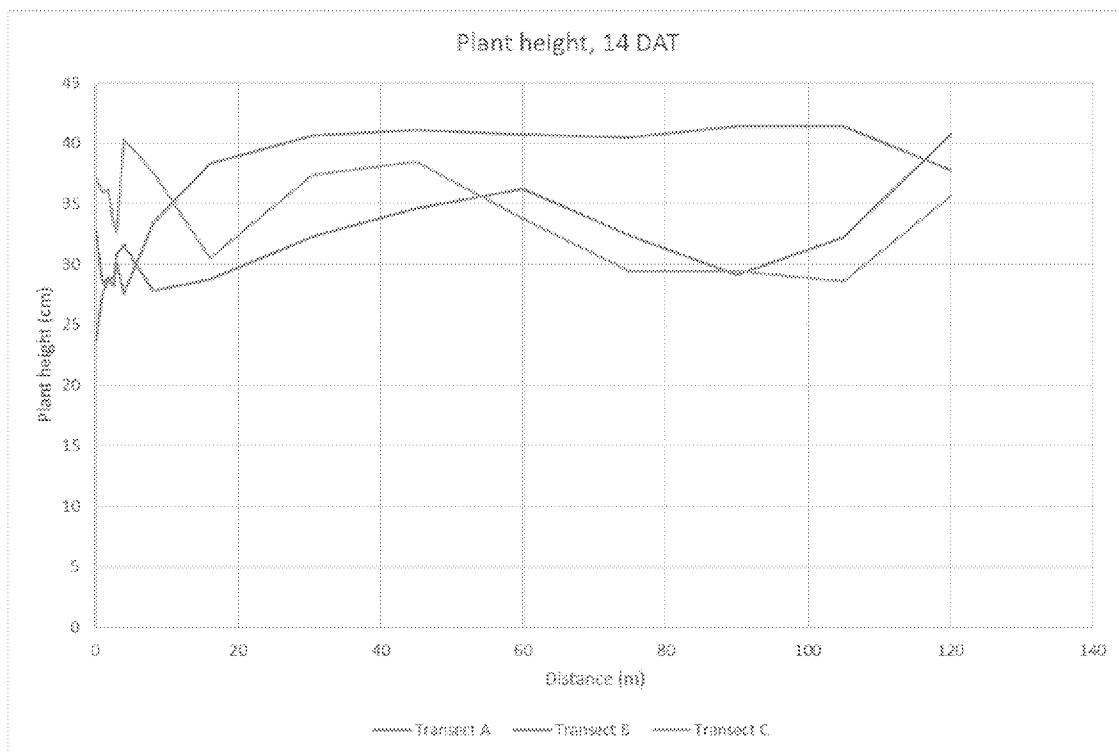
Figure E.15. Plant height, 14 DAT, Sprague Study
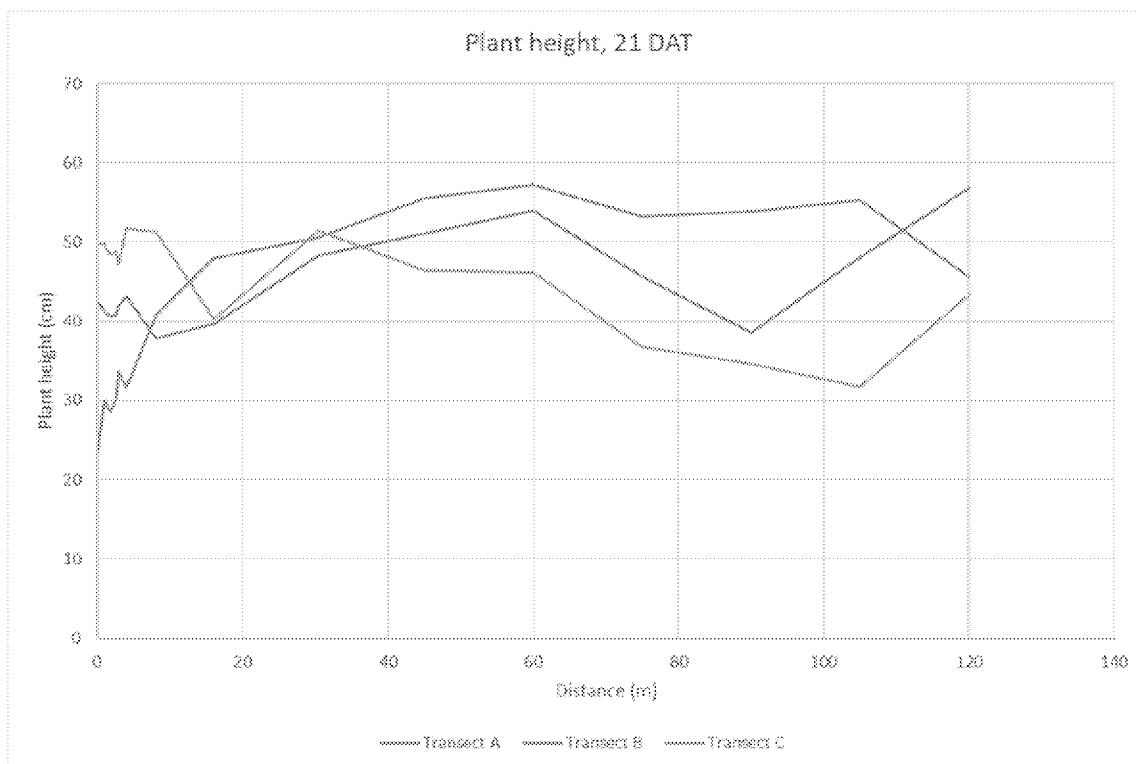
Figure E.16. Plant height, 21 DAT, Sprague Study

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In 2018, Dr. Kruger from the University of Nebraska also submitted data in support of the large field study effort (Kruger 2018). A 30-acre plot of soybeans inside of a 150-acre field was treated on 7/10/18 from 8:46-9:09 am with XtendiMax with Vaporgrip plus PowerMAX. Soybean was at the V5 growth stage and was 14 inches tall. The three downwind transects were placed to the north of the field and the upwind samplers were placed on the south. The wind direction was out of the south-southeast at the time of application. No precipitation occurred during the conduct of the study, but air temperature and relative humidity data for the were not available. Plant height effects at 21 days beyond 50 feet were not observed, regardless of the direction from the application area. The average distance to 5% plant height reduction for the three transects was 10 m. Plots of visual injury with distance for the uncovered transects are provided in **Figure E.17**. Slight visual symptomology was observed approximately 250 feet beyond the edge of the field. Covered plants did not show a change in plant height with distance. Visual injury to covered plants at 21 days did not vary with distance for two of the transects but did for the third. Visual injury ranged from 25-40% at 30 feet from the treated field for covered plants. While air concentrations and deposition were measured, measurement values were not provided to EPA, so EPA could not evaluate the flux rates from the study.
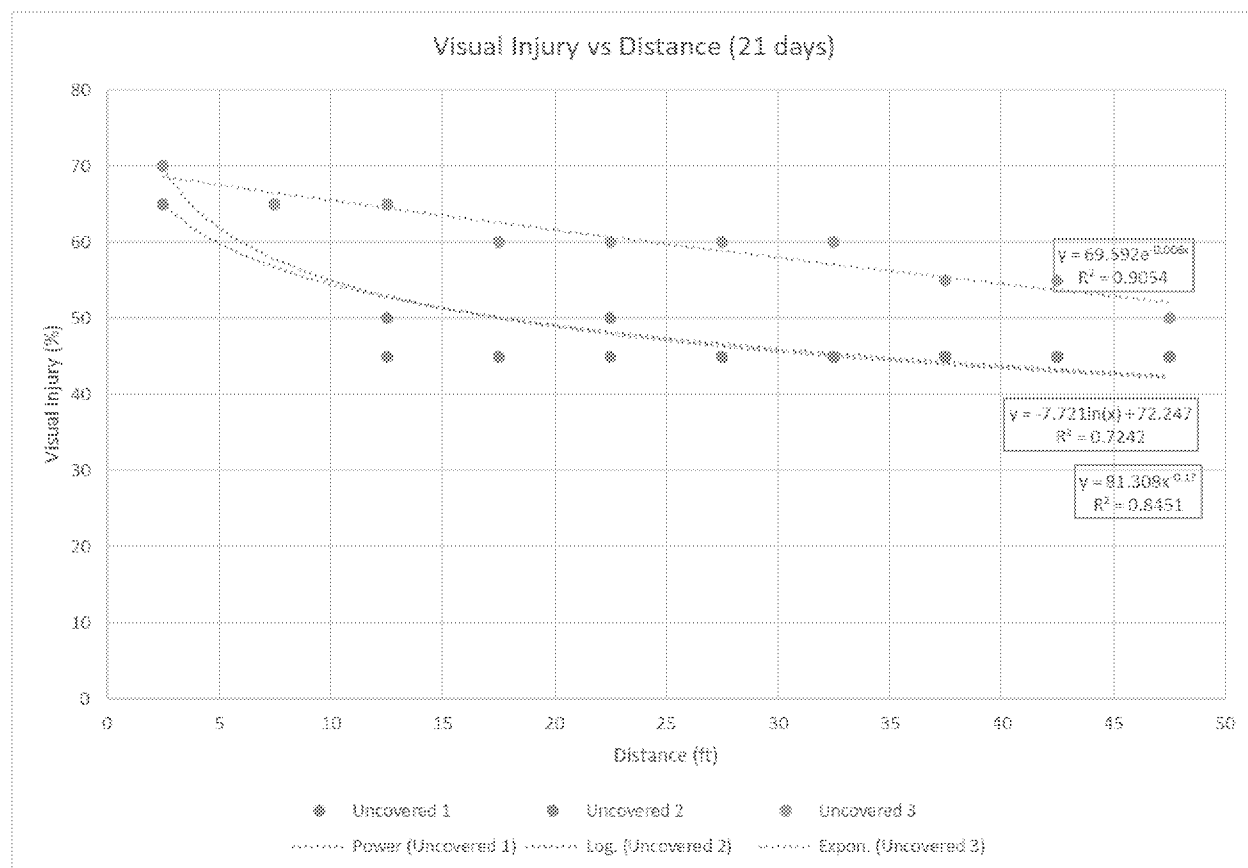
Figure E.17. Visual Injury, 21 DAT, Kruger Study

1.2. Engenia

1.2.1. Registrant Submitted Studies

In April 2016, a field volatility study was conducted on two fields in Plains, GA (MRID 49937701) as part of a new product registration application. The test substance used in the field phase of these studies was Engenia containing dicamba BAPMA salt (599 g a.e./L). The plot dimensions were approximately 120 meters by 120 meters (3.6 A) in GA for both fields. The test plots were a mix of hay, Bermuda grass, and Orchardgrass and were treated at a rate of 1 lb a.e./A. The vegetation was roughly 6-8 inches in height at one site (Site 1W) and 15-18 inches at the second site (Site 2E) at the time of dicamba application (boom height not specified). The spray application was made to the test plots at 9:19 am (Site 1W) and 10:23 am (Site 2E) on April 11th. Maximum temperatures during the first 24 hours ranged from 87-100°F and 85-99°F on Day 2. Maximum relative humidity ranged from 42-98%; soil pH was not specified. The maximum 24-hour average concentrations from air modeling from AERSCREEN runs performed by the study authors was 538 ng/m^3 at the edge of the field. The maximum deposition value from AERSCREEN runs performed by the study authors was 1.11×10^{-7} lb a.e./A at the edge of the field.

In June 2016, a field volatility study was conducted on two fields in Plains, GA (MRID 50020301) as part of a new product registration application. The test substance used in the field phase of these studies was Engenia containing dicamba BAPMA salt (599 g a.e./L). The plot dimensions were approximately 120 meters by 120 meters (3.6 A) in GA for both fields. The test plots were a mix of hay and Bermuda grass and were treated at a rate of 1 lb a.e./A. The vegetation was roughly 6-10 inches in height at both sites (Site 1W and Site 2E) at the time of dicamba application (boom height not specified). The spray application was made to the test plots at 11:07 am (Site 1W) and 12:03 pm (Site 2E) on June 13th. Maximum temperatures during the first 24 hours ranged from 69-79°F and 62-78°F on Day 2. Maximum relative humidity ranged from 55-99%; soil pH was not specified. The maximum 24-hour average concentrations from air modeling from AERSCREEN runs performed by the study authors was 4,115 ng/m^3 at the edge of the field. The maximum deposition value from AERSCREEN runs performed by the study authors was 3×10^{-3} lb a.e./A at 1000 ft the edge of the field.

1.2.2. Academic Studies

In 2018, Dr. Young from Purdue University also submitted data for DT soybeans treated with Engenia (Young 2018b). Two separate plots, each 0.9 acres (200 ft x 200 ft) of DT soybeans in the center of a 15-acre field (800 ft x 800 ft) of non-DT soybeans at the V5 stage, were treated on 8/3/2018. Plots were treated 24 and 48 inches above the canopy, using TTI11003 nozzles (it should be noted that the Engenia label specifies that the boom height should not exceed a height of 24 inches above the crop canopy). The air temperature during the application was 95°F and the relative humidity was 56%. Winds during the application were out of the southwest at 1-5 mph. Temperature during the first 28 days of the study ranged from 51 to 91°F and relative humidity ranged from 34 to 100%. Wind speed and wind direction are depicted in **Figure E.18**. The majority of the time the wind was blowing from the southwest. Meteorological data were not available to assess whether inversion conditions occurred during the study. Visual plant injury measurements were taken at 14 and 28 DAT every 40 ft on all sides of the field, with additional measurements along a 45 degree at each corner. Three measurements were taken along each transect; the distance to where the extent of symptoms > 30%; the distance to where the extent of >10% symptoms; and the distance to where no symptoms would be visible. Visual injury results are provided in **Table E.3**. At 14 DAT, the maximum average distance to greater than 30% visual injury occurred along the north side at 31 ft, with a maximum distance to greater than 30% injury at 82 ft (east

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side) for plot 1. At 28 DAT, the maximum average distance to greater than 30% visual injury occurred along the east side at 26 ft, with a maximum distance to greater than 30% injury at 108 ft for plot 1. Plot 2 results are also provided in **Table E.3,** but these results were generated using a boom height 48 inches above the canopy, which is not in accordance with the label. While air concentrations and deposition were measured, measurement values were not provided to EPA, so EPA could not evaluate the flux rates from the study.
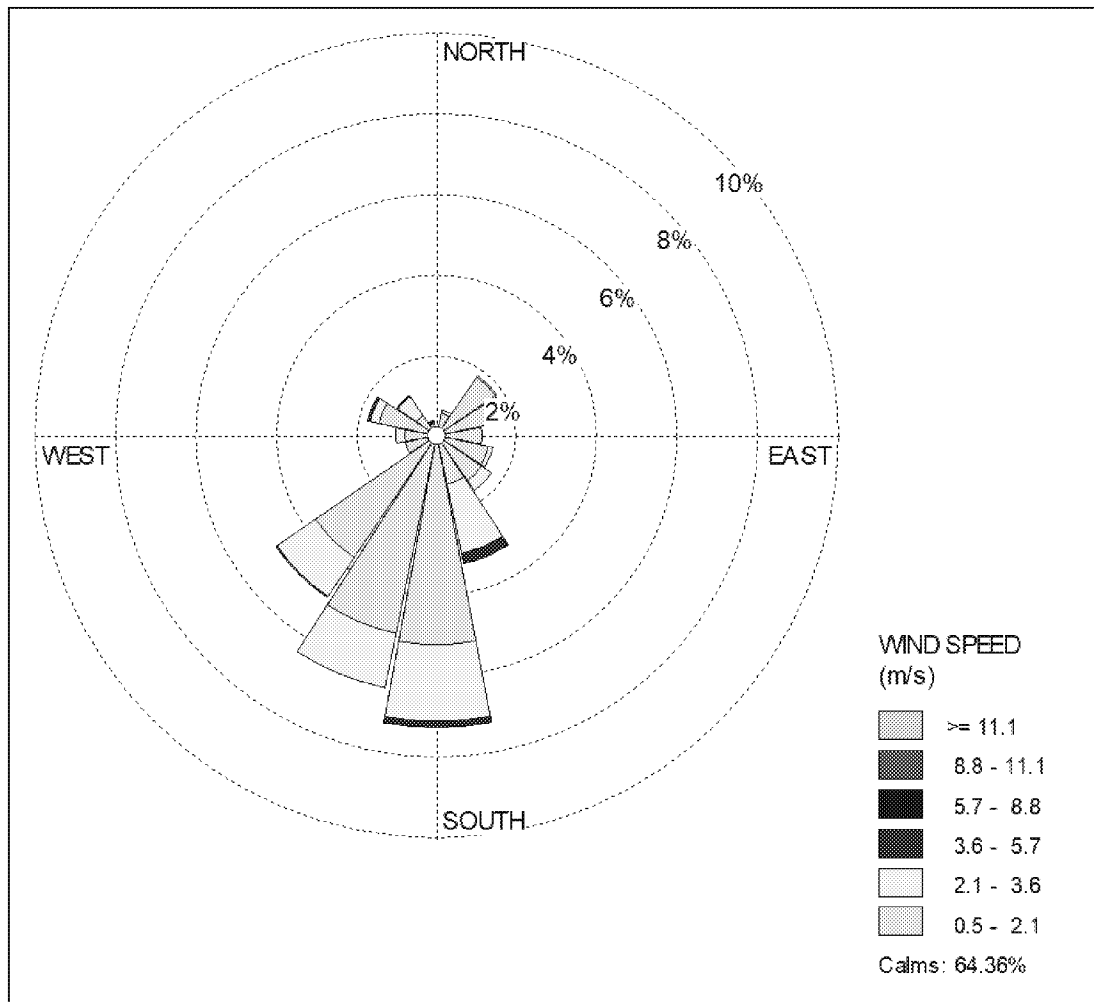
Figure E.18. Meteorological Data, Young Engenia Study (direction from which wind was blowing)

Table E.3. Distance to Visual Injury (m)

Side/Transect	14 DAT Average Distant (Min – Max)			28 DAT Average Distant (Min – Max)		
	> 30%	10-30%	< 10%	> 30%	10-30%	< 10%
Plot 1						
North	10 (3 – 21)	16 (5 – 43)	19 (6 – 50)	5 (2 – 18)	11 (4 – 19)	13 (5 – 23)
East	7 (1 – 25)	11 (1 – 33)	21 (5 – 34)	8 (0 – 33)	10 (1 – 33)	12 (1 – 34)
South	0 (0 – 1)	1 (0 – 2)	5 (2 – 8)	0 (0 – 1)	0 (0 – 1)	1 (0 – 3)
West	1 (1 – 3)	3 (2 – 5)	6 (3 – 7)	1 (0 – 3)	2 (1 – 4)	3 (1 – 5)
Diagonals	2 (0 – 5)	4 (1 – 8)	8 (2 – 11)	1 (0 – 3)	4 (0 – 8)	4 (1 – 9)
Plot 2						
North	31 (1 – 80)	31 (11 – 55)	34 (16 – 59)	27 (1 – 79)	32 (3 – 80)	41 (10 – 81)
East	11 (2 – 16)	15 (2 – 21)	21 (5 – 29)	8 (1 – 12)	22 (8 – 29)	32 (8 – 44)
South	51 (0 – 135)	34 (2 – 102)	65 (4 – 129)	17 (0 – 96)	20 (1 – 98)	34 (4 – 100)
West	1 (1 – 2)	2 (2 – 4)	4 (2 – 5)	1 (0 – 2)	2 (1 – 3)	3 (2 – 4)
Diagonals	7 (0 – 26)	10 (1 – 36)	24 (3 – 52)	3 (0 – 10)	11 (1 – 39)	18 (2 - 62)

2. Studies Submitted Post 2018

As part of the 2018 conditional registration that was vacated in 2020, registrants were required to conduct and submit off-field movement (OFM) studies, designed to reduce the uncertainties in the decision. These field studies examined off-site movement of dicamba and evaluated the impacts on plant height and yield from primary and secondary drift off-target. The studies represented varied geographic areas and include locations where high numbers of complaints have been logged and ranges of environmental conditions.

The following sections discuss the conduct and results of these studies, as well as additional studies submitted in support by academics and studies that explored the use of VRAs (pH buffering agents) designed to reduce the volatility of dicamba in the field.

2.1. XtendiMax with Vaporgrip

2.1.1. Registrant Submitted Studies

2.1.1.1. Mississippi Study (MRID 51017501)

In June 2019, a field volatility study was conducted in Washington County, MS. The design included a test plot of approximately 24 acres (340 m by 340 m) of dicamba-tolerant soybeans, in the center of a 108-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on April 29, 2019 and replanted on May 24, 2019 as a result of seed damage due to heavy rain and flooding. The test plot was treated with XtendiMax with VaporGrip, RoundUp PowerMAX, and Intact (a drift reduction agent) on June 22, 2019 at 14:15. A single application of 0.5 lb dicamba/A was made using a Case IH Patriot 3230 ground sprayer equipped with a 90 ft boom and 54 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 20 inches apart, at a boom height of 20 inches above the crop canopy (6.7 in). A spray drift test system consisted of three downwind transects (north side of field) perpendicular to the treated area, along with two transects on the east, west, and

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south sides of the treated field and transects along the diagonals. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 90 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 90 m and along the diagonals of the field to evaluate volatility (covered with tarps at time of application) and spray drift exposure (uncovered). Six upwind control areas were also identified and evaluated for plant height and dicamba specific VSI. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application; plants were actually covered for up to 2 hours, one transect (DWC) was excluded because of damage from the excess heat. Along each study transect, plant heights and VSI were measured 0, 16 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 90 m sample analyzed along the northern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of and after application ranged from 19.5-34.6°C (67.1-94.3°F), 21.7-46.9°C (71.1-116.4°F), and 56-98%, respectively. The pH of the tank mix was 4.85.

EPA estimated flux rates from the study were slightly higher than the maximum flux rates evaluated prior to the 2019 (**Figure E.19**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 15.0 to 24.3 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 7.78 to 9.50 $\mu g/m^2$. Spray drift deposition from the edge of the field to reach the NOAEC for soybean ($2.6x10^{-4}$ lb ae/A) was 9.4 m (7.7 to 10.4 m for the three transects) and 8.5 m (6.6 to 11.5 m for the two transects) in the downwind and left wind directions, respectively. It should be noted that a heavy thunderstorm event occurred on Day 2, between hours 24 and 48 of the study, which affected the volatility and plant effects measurements.
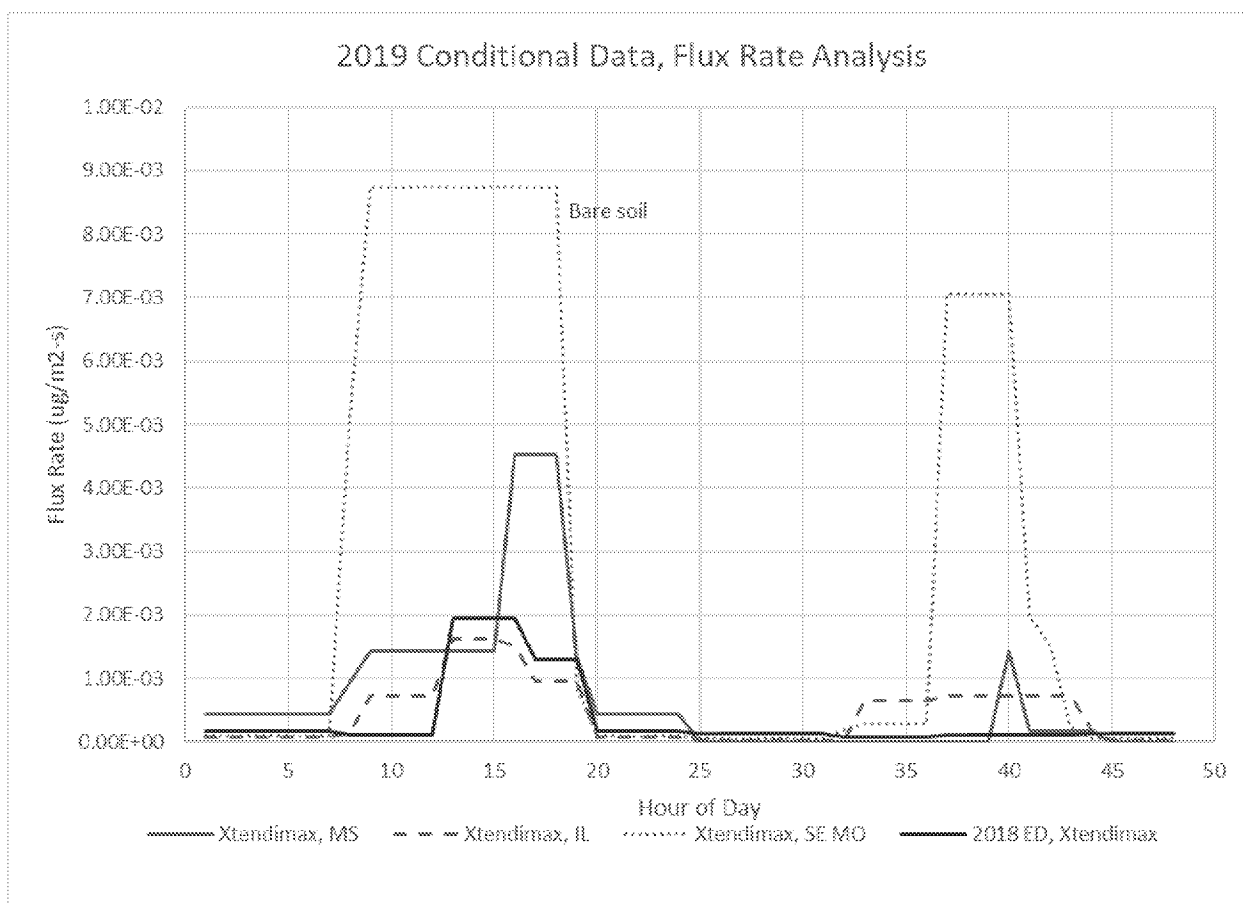
Figure E.19. Comparison of Flux Rates from Conditional Studies, XtendiMax with Vaporgrip

At 28 DAT, up to 10% VSI was reported in the downwind volatility transects (DWA, DWB; covered) for the entire 20 m of the transects. All other volatility transects less than 10% VSI within 3 m from the treated field (**Table E.4**). Visual symptomology in the downwind spray drift (uncovered) transects was more pronounced compared to the downwind volatility transects. Visual symptomology in the DW, LW, and NE spray drift transects decreased with increased distance from the treated area ranging from 35 to 50% at 5 m and 10 to 35% at 90 m.

Significant reductions in plant heights were also observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DW, LW and NE transects, **Table E.4Table E.4.**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field. Because the control plots were all clustered together beyond the upwind transects, they didn't capture the variability in plant height across the entire field. Therefore, due to the non-uniformity of plant height across the field, there increased uncertainty in the distance estimates based on a 5% reduction relative to the control growth. The impact of dicamba specific reductions in plant height are confounded by field conditions and differential growth rates across the non-tolerant soybean crop such that reduction of expected plant height (i.e., 5% reduction of mean control height) as a result of dicamba exposure is likely masked by the variable nature of conditions in the field.

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Table E.4. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA[a]	56.2[e]	109.0[c]	13.7[e]	>20[f]
DWB[a]	58.8[e]	91.8 [b,d]	16.0[e]	>20[f]
DWC[a]	67.3[e]	>90 [b,f]	-	-
LWA	16.1[e]	48.7[e]	<5[f]	<3[f]
LWB	11.1[e]	50.4[c]	>5[f]	<3[f]
NE	22.1[e]	44.0[e]	-	-
RWA	<10[f]	<3[f]	2.8[e]	<3[f]
RWB	<10[f]	<3[f]	7.8[e]	<3[f]
SE	<10[f]	<3[f]	-	-
SW	>60[f]	<3[f]	-	-
UWA	<10[f]	<3[f]	<5[f]	<3[f]
UWB[a]	>60[f]	>90[b,f]	12.2[e]	>20[f]

[a] Study authors indicate flooding may have impacted these transects
[b] DWC Injury showed a shallow dose response with effects ranging from 50% at 5 meters to 35% at 90 meters. UWB injury ranged from 20-25% for the extent of the transect.
[c] distance estimated with linear regression
[d] distance estimated with polynomial regression
[e] distance estimated with logistic regression
[f] distance estimated visually

There are several concerns with the conduct and conditions of this study. In terms of the utility of the flux rates and the volatility transects (covered transects), a heavy thunderstorm event occurred on Day 2, between hours 24 and 48, reducing the emissions from volatility. This reduction will have an impact the amount of material that the transects may have been exposed to. Distances based on vapor exposure alone (covered transects) will reflect plant responses to this lowered exposure and may underestimate distances under conditions of no rainfall.

There are signs of dicamba movement with runoff following the rainfall events. Two of the five control plots had 30-40% VSI related to floodwater exposure. EPA excluded these from the calculation of control average height for the distance estimates analyses. This reduction of number of controls has minimal impact on the interpretation of the study results. Additionally, upwind transect UWB also showed significant impacts to plant height and VSI as related to exposures through runoff. EPA also excluded this transect from the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

2.1.1.2. Illinois Study (MRID 51017502)

In August 2019, a field volatility study was conducted in Effingham County, Illinois. The design included a test plot of approximately 19 acres (274 m by 274 m) of dicamba-tolerant soybeans, in the center of a 160-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on June 13, 2019 and replanted on July 15, 2019 as a result of seed damage due to significant precipitation and saturated soil conditions during germination. The test plot was treated with XtendiMax with VaporGrip, RoundUp PowerMAX, and Intact (a drift reduction agent) on August 8, 2019 at 11:35. A single application of 0.5 lb dicamba/A was made using a Rogator 1074 ground sprayer equipped with a 100 ft boom and 60 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 20 inches apart, at a boom height of 20 inches above the crop canopy (7.9 in). A spray drift test system consisted of three downwind transects (northeast side of field) perpendicular to the treated area, along with two transects on the southeast, southwest, and northwest sides of the treated field and transects along the cardinal directions. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 120 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 120 m and along the cardinals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Four upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application; plants were actually covered for up to 1.5 hours. Along each transect, plant height and VSI were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 120 m sample analyzed along the north eastern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 18.7-31.0°C (65.7-87.8°F), 20.1-36.8°C (68.8-98.2°F), and 62-98%, respectively. The pH of the tank mix was 4.67 prior to application.

EPA estimated flux rates from the study were comparable to the maximum flux rates evaluated prior to 2019 (**Figure E.19**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 5.7 to 9.0 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 3.25 to 4.25 μg/m^2. Spray drift deposition from the edge of the field to reach the NOAEC for soybean (2.6×10^{-4} lb ae/A) was 4.95 m (3.1 to 6.3 m for the three transects) and 3.83 m (3.0 to 6.0 m in the two transects) in the downwind and left wind directions, respectively.

At 28 DAT, up to 5% VSI was reported within 5 m of the treated field (**Table E.5**). Visual symptomology in the downwind spray drift (uncovered) transects was more pronounced compared to the downwind volatility transects. Visual symptomology in the DW, LW, E-Diag, and S-Diag spray drift transects

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decreased with increased distance from the treated area ranging from 20 to 60% at 5 m and <5% at 60 m.

Significant reductions in plant heights were observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DW, LW transects, **Table E.5**). Because of significant flooding, the impact of dicamba specific reductions in plant height are confounded by field conditions and differential growth rates across the non-tolerant soybean crop.

Table E.5. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA	7.0 [e]	21.4 [e]	<3	<3
DWB[a]	19.9 [e]	36.2 [e]	<3	<3
DWC	23.9 [e]	35.0 [e]	<3	<3
LWA	4.2 [e]	15.7 [e]	<3	<3
LWB[a]	31.3 [c]	39.7 [c]	<3	<3
E Diag	27.4 [d]	53.3 [d]	<3	<3
RWA	<3	<3	<3	<3
RWB	<3	<3	<3	<3
N Diag[a]	<3	<3	<3	<3
S Diag[a]	9.1 [e]	22.3 [e]	<3	<3
UWA[a]	NA	NA	<3	<3
UWB[b]	5.3 [e]	>20 [f]	<3	<3

[a] Study authors indicate flooding may have impacted these transects
[b] reported that runoff from the treated field may have impacted transect out to 40 m.
[c] distance estimated with linear regression
[d] distance estimated with polynomial regression
[e] distance estimated with logistic regression
[f] distance estimated visually

There are several concerns with the conduct and conditions of this study. Notably, this study was conducted late in the summer with plants that were planted in July and final assessment of effects being observed in September. It is unclear how this late season study may relate to potential reductions of plant growth and manifestation of VSI when exposed during the typical vegetative growing season (May-July).

A total of 2 inches of rainfall occurred between the third and fifth days of the study. While this may not have had a significant impact on the volatilization of dicamba, as most of the dicamba is emitted in the first 24 hours, there were signs of dicamba movement with runoff following the rainfall events. Transect UWB showed impacts to plant height and VSI as related to exposures through runoff, signaled by increasing VSI with increasing distance from the treated field. Other transects (e.g., UWA) had low spots

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with extremely stunted plant height in the middle of the transect, suggesting a low spot with either reductions of growth related to soil saturation or dicamba exposure. Because of the uncertainties of the late season and the number of transects impacted by flooding, EPA excluded this study from the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

2.1.1.3. Missouri Study (MRID 51017503)

In September 2019, a field volatility study was conducted in New Madrid County, Missouri. The design included a test plot of approximately 19 acres (274 m by 274 m) of dicamba tolerant soybean, in the center of a 150-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on August 1, 2019; however, the test plot was disked to bare ground and the crop destroyed on September 10, 2019 due to the soybeans beginning bloom (R1 stage) which would have violated the product label. After the crop destruct, the bare ground test plot was treated with XtendiMax with VaporGrip, RoundUp PowerMAX, and Intact (a drift reduction agent) on September 11, 2019 at 11:27 am. A single application of 0.5 lb dicamba/A was made using a John Deere R4030 ground sprayer equipped with a 90 ft boom and 73 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 15 inches apart, at a boom height of 20 inches above the crop canopy (9.8 in). A spray drift test system consisted of three downwind transects (northeastern side of field) perpendicular to the treated area, along with two transects on the southeast, southwest, and northwest sides of the treated field and transects along the cardinals. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 120 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 120 m and along the cardinals of the field to evaluate volatility and spray drift exposure. Eight upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application; plants remained covered for up to 1.75 hours. At each study transect, plant heights and visual symptomology were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 120 m sample analyzed along the northeastern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 24.6-33.2°C (76.3-91.8°F), 26.5-45.9°C (79.7-114.7°F), and 46-83%, respectively. The pH of the tank mix was 4.82 prior to application.

EPA estimated flux rates from the study were higher than the maximum flux rates evaluated in previous studies (**Figure E.19**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 16.7 to 25.2 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 9.67 to 12.76 $\mu g/m^2$. It should be noted that the application was made to a bare soil plot, so flux rates will tend to different than those for the other studies where the applications were made to soybean fields. Spray drift deposition from the edge

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of the field to reach NOAEC for soybean (2.6×10^{-4} lb ae/A) was 9.4 m (7.7 to 10.4 m for the three transects) in the downwind direction.

Significant reductions in plant heights were observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DW transects, **Table E.6**). Because of late planting, the impact of dicamba specific reductions in plant height are confounded by lack of significant growth across the non-tolerant soybean crop such that reduction of expected plant height (i.e., 5% reduction of mean control height) as a result of dicamba exposure is likely not captured.

Table E.6. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA	17.5[b]	57.0[a]	<3 [d]	13.6[b]
DWA-D	20.9[a]	11.7[a]	NA	NA
DWB	29.0[a]	48.0[a]	<5	20.1[b]
DWC	62.0[b]	87.5[a]	9.9[a]	10.6[a]
DWC-D	20.2[b]	19.7[a]	NA	NA
LWA	<3[d]	<3 [d]	<20 [d]	<3 [d]
LWB	<20 [d]	<10 [d]	<3 [d]	<3 [d]
RWA	<3 [d]	<3 [d]	<3 [d]	<3 [d]
RWB	<3 [d]	26.9[c]	<10 [d]	<5 [d]
UWA	<20 [d]	<3 [d]	<3 [d]	<3 [d]
UWB	<3 [d]	<3 [d]	<3 [d]	<3 [d]
UWB-D	<20 [d]	<3 [d]	NA	NA

[a] distance estimated with logistic regression
[b] distance estimated with polynomial regression
[c] distance estimated with linear regression
[d] distance estimated visually

The delay of the start of the study resulted in significant delay to the plant effect portion of the study such that plant effects were observed in late August and September. The study authors indicated that there was little change in plant height between the 14-DAT measurement and the 28-DAT measurement. Additionally, the study authors made the dicamba application to a bare field rather than the standing DT-soybean crop. Because of these uncertainties, EPA excluded this study from the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

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2.1.2. Academic Studies

In 2019 several academic scientists conducted studies looking at the volatility, spray drift, and/or plant effects from applications of dicamba, specifically XtendiMax with Vaporgrip. The results of the analysis are discussed below.

2.1.2.1. Auburn University

From June 26 to 29, 2019, Dr. Li of Auburn University conducted a field study in Deatsville, AL, where two 5-acre fields, planted with dicamba tolerant soybean, were treated with XtendiMax with Vaporgrip plus Roundup PowerMAX plus Intact (application rate unspecified, but assumed to be 0.5 lb ae/A) from 9 am to noon (Li, 2020). Potted soybean plants were placed around the fields along transects in the cardinal and diagonal directions at 0, 15, 25, 50, and 100 ft away from the edge of the field 30 minutes after application. The plants were collected 48 hours later and returned to the greenhouse, where they were assessed for visual injury at 14 and 28 days after treatment. The plant portion of the study could not be used in this assessment because there was contamination of the controls and plants that remained in the greenhouses throughout the study. VSI was reported for a large portion of plants, with similar to magnitude of effects that were observed in the intestinally exposed plants from the field experiment. Therefore, it was not possible to discern what exposure lead to the plant injury.

In addition, an off-target movement study was conducted on a 5 A field of dicamba-tolerant soybean that was treated with XtendiMax plus Roundup PowerMAX plus Intact at 0.5 lb ae/A on 8/6/2019 at 4:15 pm. Air samples were collected using a mast at the center of the field at heights of 0.15, 0.3, 0.55, and 0.9, with duplicate samples collected at 1.5 m for 2.5 days. Spray drift samples were also collected along 8 transects surrounding the field at distances of 6, 9.3, 19, 25.6, 32, 65, 99, 130, 163, and 196 feet from the edge of the field. Temperatures ranged from $22 - 37$ °C ($72 - 99$ °F) during the study. Flux rates were slightly higher, but comparable to those presented prior to 2019 (**Figure E.20**). Maximum deposition values from spray drift along the transects ranged from 1.96×10^{-4} to 1.27×10^{-3} lb ae/A. Based on deposition curves derived using the spray drift data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were all less than 6 ft.

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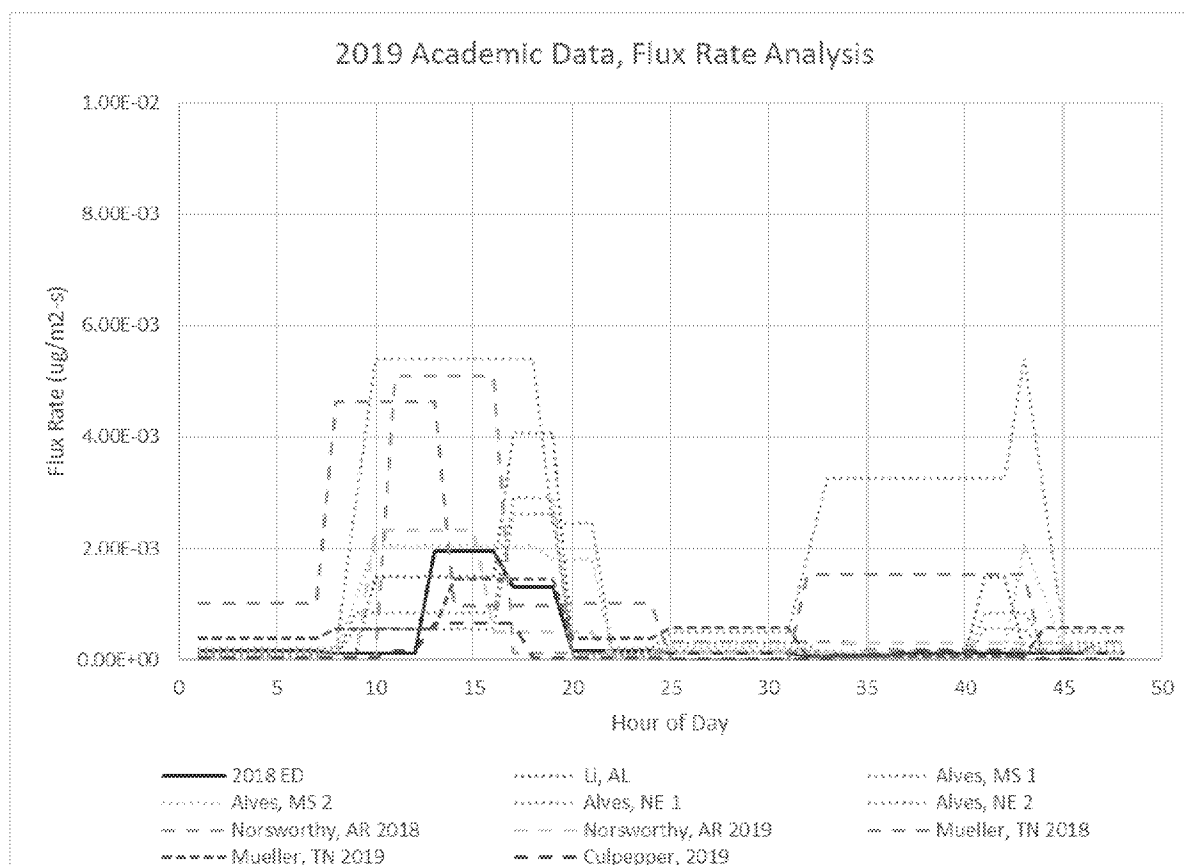
Figure E.20. Comparison of Dicamba Flux Rates for Submitted Academic Studies

2.1.2.2. University of Tennessee

In 2018 and 2019, Dr. Mueller of the University of Tennessee investigated the volatility of dicamba on 100 ft x 100 ft (0.23 A) fields of dicamba-tolerant soybean (approximately 100,000 seeds per acre and in 30 in rows) at the R1 stage (Mueller 2020). The pH of the soil was 6.2. Fields were treated with XtendiMax with Vaporgrip, PowerMAX, and Intact at a rate of dicamba at 0.5 lbs ae/A. High volume (185 L/min) and low volume (3 L/min) air samplers were placed at the four cardinal directions as well as the four diagonals, and air samples were collected 0-6, 6-12, 12-24, and 24-36 hours after treatment (HAT), with the 2019 study also collecting samples 36-48 and 48-60 HAT. Applications occurred on 9/12/18 and 6/26/19, between the hours of 7 and 8 am. Flux rates were derived using the direct flux method. Temperatures ranged from 21 – 31°C (70 – 88°F) and 16 – 32°C (61 – 90°F) during the study in 2018 and 2019, respectively. Flux rates were slightly higher in 2018 and slightly lower in 2019 than those presented prior to 2019 (**Figure E.20**). In 2019, bioassay potted plants at the V1-V2 stage were placed at the sampler locations for various durations and VSI were reported at 7, 14, and 21 days after treatment (DAT), with plant height measured at 21 DAT. However, control contamination and a lack of available plant response data resulted in the bioassays not being suitable for analysis.

2.1.2.3. University of Arkansas

In 2018 and 2019, Dr. Norsworthy of the University of Arkansas investigated the volatility of dicamba on 200 ft x 200 ft (0.46 A) and 100 ft x 100 ft (0.23 A) fields, respectively, of dicamba-tolerant soybean

(approximately 140,000 seeds per acre and in 36 in rows) at the R1 stage (Mueller 2020 and Norsworthy 2020). The pH of the soil was 5.5 and 6.8 in 2018 and 2019, respectively. Fields were treated with XtendiMax with Vaporgrip, PowerMAX, and Intact at rate of dicamba at 0.5 lbs ae/A on 7/31/2018 and 7/11/2019 between 8 and 9 am. High volume (185 L/min) and low volume (3 L/min) air samplers were placed at a distance of 5 ft from the treated field in the four cardinal directions as well as the four diagonals, and air samples were collected 0-6, 6-12, 12-24, 24-36, 36-48 and 48-72, and 72-96 hours after treatment (HAT), with the 2019 study collecting samples through 48 HAT. Temperatures ranged from $16 - 31°C$ ($61 - 88°F$) and $18 - 29°C$ ($64 - 84°F$) during the study in 2018 and 2019, respectively. Flux rates were derived using the direct flux method. Flux rates were slightly higher in 2018 and slightly lower in 2019 than those presented prior to 2019 (**Figure E.20**).

The field studies conducted in 2018 and 2019 included greenhouse grown potted soybean plants (R1 growth stage) which were set above the canopy of the treated soybean crop after application to the soybean field in order to evaluate the plant response to exposure to dicamba related to volatility. For discussion of the plant effects see **Appendix C**.

2.1.2.4. University of Nebraska

In 2018, Dr. Alves of the University of Nebraska investigated the volatility of dicamba on 2, 10-acre fields in Roscoe, Nebraska and 2, 9-acre fields in Starksville, Mississippi of dicamba-tolerant soybean (Alves 2020). One field at each location was treated at the V3 stage and one field at each location was treated at the R1 stage. All fields were treated with XtendiMax with Vaporgrip, PowerMAX, and Intact at rate of dicamba at 0.5 lbs ae/A on 6/27/2018 (5:30 pm) and 7/20/2018 (4 pm) at the Mississippi and Nebraska fields, respectively. Air samples were collected for 2.5 days using a mast at the center of the field at heights of 0.15, 0.3, 0.55, 0.9, and 1.5 m above the crop (0.58 and 0.61 m for the crops at R1 and 0.25 and 0.36 m at the V3 stage). Spray drift samples were also collected along 3 transects in each of the cardinal directions from the field at distances of 4, 8, 16, 31, and 45 meters from the edge of the field. Temperatures ranged from $22 - 36°C$ ($72 - 97°F$) and $18 - 34°C$ ($64 - 93°F$) in Mississippi and Nebraska, respectively, during the study. Flux rates were derived using the aerodynamic and integrate horizontal flux methods. Flux rates were slightly higher at the Mississippi sites and slightly lower at the Nebraska sites than those presented prior to 2019 (**Figure E.20**). Maximum deposition values from spray drift along the transects were 2.49×10^{-3} and 2.71×10^{-4} lb ae/A in Mississippi and Nebraska, respectively. Based on deposition curves derived using the spray drift data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were all less than 68 ft in Mississippi and less than 16 feet in Nebraska.

The plant bioassay data from the Mississippi location was missing a substantial amount of the replicate data from block 1, VSI were between 10 and 20% for the entire covered and uncovered transects in block 1. Plant data for block 2 are all provided and show VSI across the entire covered (10% only within 1.5 m, all other distances had 5%VSI) and uncovered transects (5-10% VSI with no pattern of distance). The Nebraska location had a significant distance to effect response for VSI with 10% estimated out to 10-11m for the uncovered transects and <3 m for both covered transects. EPA excluded this study from the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

### 2.1.2.5. University of Georgia

In 2019, Dr. Culpepper of the University of Georgia investigated the volatility of dicamba on a 8-acre field of dicamba-tolerant soybean in Georgia (MRID 51134102). The field was treated with XtendiMax

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with Vaporgrip, PowerMAX, and Intact at rate of dicamba at 0.5 lbs ae/A on 9/10/2019 at 12:30 pm. The field was irrigated for 7 hours after the application to examine the impact of watering in dicamba after an application on volatility. Air samples were collected for 2.5 days using a mast at the center of the field at heights of 0.15, 0.3, 0.55, 0.9, and 1.5 m above the crop (crop height not specified). Spray drift samples were also collected along 2 transects in each of the cardinal directions from the field at distances of 2, 3, 4, 6, 8, 10, 15, 23, 30, 40, and 60 meters from the edge of the field. Temperatures ranged from 19 – 36°C (66 – 97°F) during the study. Flux rates were derived using the aerodynamic and integrate horizontal flux methods. Flux rates were lower than those presented prior to 2019 (**Figure E.20**). Maximum deposition value from spray drift along the transects was 1.32×10^{-4} lb ae/A. Based on deposition data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were less than 2 meters from the field.

2.1.3. XtendiMax with Vaporgrip plus VaporGrip X

In 2020, registrants and academics submitted field study data to support the inclusion of a VRA (pH buffering agent), VaporGrip X, designed to reduce the potential for volatile emissions of dicamba. Below is a summary of the submitted studies. In general, the addition of the Vaporgrip X reduced emissions.

2.1.3.1. Registrant Submitted Studies

2.1.3.1.1. Illinois Study (MRID 51111901)

In July 2019, a field volatility study was conducted in Clinton County, Illinois. The design included a test plot of approximately 21 acres (293 m by 296 m) of dicamba tolerant soybean, in the center of a 117-acre agricultural field planted with non-tolerant soybean planted on June 3, 2019. The test plot was treated with MON 76980 (DGA salt of dicamba), MON 79789 (potassium salt of glyphosate), Intact (a drift reduction agent), and MON 51817 ("*Vaporgrip X*") on July 2, 2019 at 9:35.A single application of 0.5 lb dicamba/A and 1.75 lb/A of MON 51817 was made using a John Deere R4038 ground sprayer equipped with a 120 ft boom and 96 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 15 inches apart, at a boom height of 20 inches above the crop canopy (6 in). A spray drift test system consisted of three downwind transects (northern side of field) perpendicular to the treated area, along with two transects on the south, east, and west sides of the treated field and transects along the diagonals. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 90 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 90 m and along the cardinals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Eight upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application; plants were actually covered for up to 49 minutes after application. Along each transect, plant height and VSI were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each

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transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 90 m sample analyzed along the downwind transects).

Air temperatures and relative humidity the day of application (7/2/19) ranged from 22.3-33.4°C (72.1-92.1°F) and 46-97%, respectively. Soil temperatures were not reported. The pH of the tank mix was 5.2 prior to application.

EPA estimated flux rates from the study were about 2-3 times lower than the maximum flux rates evaluated in prior to 2019 and the XtendiMax study conducted in Illinois in 2019 (MRID 51017502 discussed above)(**Figure E.21**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 1.9 to 2.8 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 0.86 to 1.47 µg/m^2. Spray drift deposition from the edge of the field to reach NOAEC for soybean (2.6x10^{-4} lb ae/A) ranged from 8.3 to 12.3 m and 9.7 to 15.8 m along the transects in the downwind and left wind directions, respectively. It should be noted that a significant rain event (2 in) occurred between hours 36 and 48, making the flux estimates generated during and after this period uncertain.
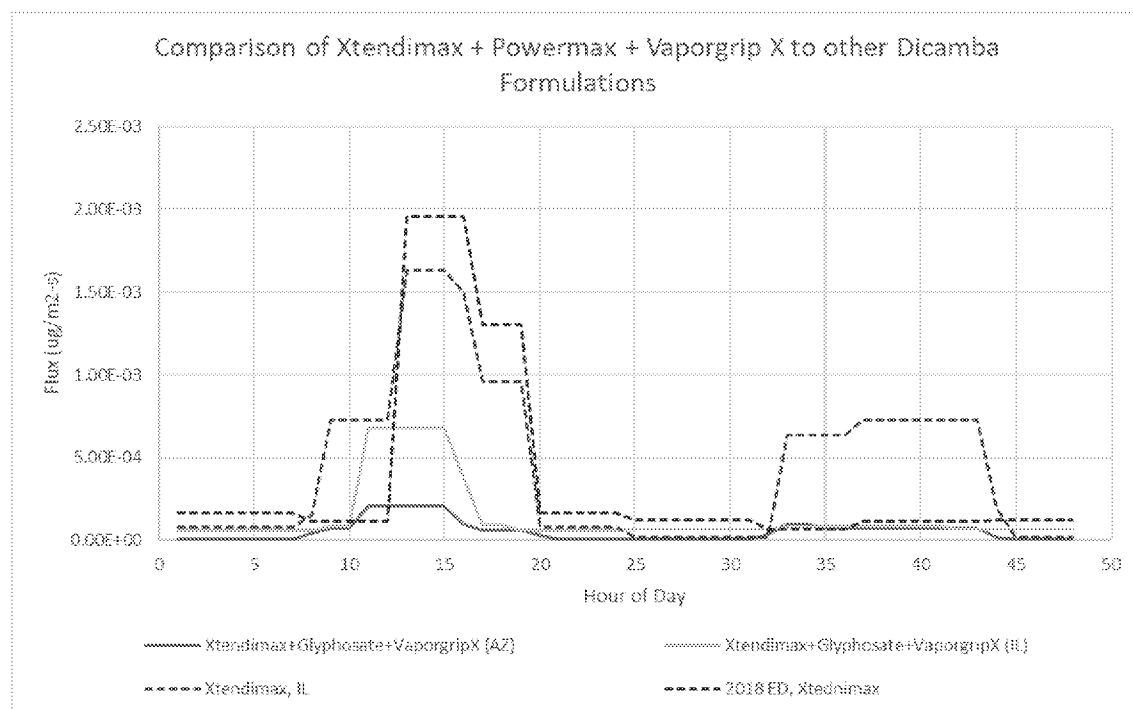
Figure E.21. Comparison of Flux Rates from VGX Field Studies to Other XtendiMax Field Studies

At 28 DAT, VSI 10 to 30% were reported for the RWA and RWB volatility transects. These transects were reported to have had been exposed to runoff leaving the treated area after a rain event that had occurred on day 2. All other volatility transects less than 5% VSI within 3 m from the treated field (**Table E.7**). The downwind spray drift (uncovered) transects was had significant VSI with distance relationships. In the DWC, LWA, LWB, and NW transects reaching out to 24.7 m. Spray drift transects decreased with increased distance from the treated area ranging from 5 to 50% at 5 m and 0 to 5% at 60 m.

Significant reductions in plant heights were also observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DW, LW and NW

transects, **Table E.7**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field due to responses of the condition of the field (notably soil moisture in low areas). Therefore, due to the non-uniformity of plant height across the field, there is uncertainty in the distance estimates based on a 5% reduction relative to the control growth.

Table E.7. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height	Distance to 10% VSI	Distance to 5% Height	Distance to 10% VSI
DWA	36.6[a]	<5[b]	16.9[a]	<3[b]
DWB	76.1[a]	<5[b]	>20[b]	<3[b]
DWC	37.3[a]	8.4[a]	<20[b]	<3[b]
LWA	>60[b]	13.4[a]	<10[b]	<3[b]
LWB	59.2[a]	11.1[a]	>20[b]	<3[b]
NE[c]	<40[b]	<40[b]	-	-
NW	35.9[a]	24.7[a]	-	-
RWA[c]	>60[b]	>50[b]	4.5[a]	22.6[a]
RWB[c]	<3[b]	<3[b]	16.9[a]	8.2[a]
SE	<60[b]	<3[b]	-	-
SW	<60[b]	<3[b]	-	-
UWA	<5[b]	<3[b]	>20[b]	<3[b]
UWB	<60[b]	<3[b]	<3[b]	<3[b]

[a] estimated using logistic regression
[b] visually estimated
[c] transects impacted by runoff exposure

There are several concerns with the conduct and conditions of this study. In terms of the utility of the volatility transects (covered transects), a significant rain event (2 in) occurred between hours 36 and 48, reducing the emissions from volatility. This reduction impacts the amount of material that the transects may have been exposed to via volatilization. Distances based on vapor exposure alone (covered transects) will reflect plant responses to this lowered exposure and may underestimate distances under conditions of no rainfall.

There are signs of dicamba movement with runoff following the rainfall events. Both RW transects and the NE transect showed significant impacts to plant height and VSI as related to exposures through runoff. EPA excluded these transects from the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

2.1.3.1.2. Arizona Study (MRID 51134103)

In May 2018, a field volatility study was conducted in Pinal County, AZ to evaluate the use of a VRA (buffering agent; MON 51817) in tank mixes applied to cotton. Two fields, approximately 9 acres (213 m

by 171 m), of dicamba-tolerant cotton were treated with MON 76980 (DGA salt of dicamba), Intact (a drift reduction agent), and MON 51817 (Treatment 1) and MON 76980 (DGA salt of dicamba), MON 79789 (potassium salt of glyphosate), Intact (a drift reduction agent), and MON 51817 (Treatment 2) on May 6, 2018 at 8:46 and 9:49, respectively. A single application of 0.5 lb dicamba/A and 1.5 lb/A of MON 51817 was made using a John Deere 4630 ground sprayer equipped with an 80-ft boom, 33 Turbo TeeJet® Induction nozzles (TTI 11006) with 30-inch spacing, and the boom height of approximately 20 inches above the crop canopy (7.3 cm, 2.9 in). A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. During application for Treatment 1, the maximum air temperature, relative humidity, and soil temperature at the surface were 85.8°F (29.9°C), 26%, and 98.1°F (36.7°C). During application for Treatment 2, the maximum air temperature, relative humidity, and soil temperature at the surface were 93.7°F (29.9°C), 18%, and 103.8°F (39.9°C). EPA estimated flux rates from the study were lower than the maximum flux rates evaluated prior to 2019 (**Figure E.21**). Plant effects beyond the treated area were not evaluated in this study, so EPA could not use this study for establishing distances to effect.

2.1.3.2. Academic Studies

2.1.3.2.1. University of Nebraska

In 2019, Dr. Kruger of the University of Nebraska investigated the volatility of dicamba on a 10-acre field of dicamba-tolerant soybean in Nebraska. The field was treated with XtendiMax with Vaporgrip, PowerMAX, Vaporgrip X, and Intact at rate of dicamba at 0.5 lbs ae/A on 8/18/2019 at 10 am (MRID 51134102). Air samples were collected for 3 days using a mast at the center of the field at heights of 0.15, 0.3, 0.55, 0.9, and 1.5 m above the crop (crop height not specified). Spray drift samples were also collected along 2 transects in each of the cardinal directions from the field at distances of 2, 3, 4, 6, 8, 10, 15, 23, 30, 40, and 60 meters from the edge of the field. Temperatures ranged from 15 – 30°C (59 – 86°F) during the study. Flux rates were derived using the aerodynamic and integrate horizontal flux methods. Flux rates were much lower than those presented prior to 2019 (**Figure E.22**). Maximum deposition value from spray drift along the transects was 7.31×10^{-4} lb ae/A. Based on deposition data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were all less than 6 meters.

Plant height and VSI were observed along the spray drift (uncovered) and volatility (covered) transects out to 60 and 15 m respectively (**Table E.8**). Low level VSI ($\leq 5\%$) was observed at random sampling distances along the S, E, and W transects, there was no distance to effect pattern. No VSI were observed along the N volatility transect. Along the spray drift transects a VSI showed a pattern of distance to effect with greatest VSI reported in the S and W transects. Plant height measures reflected high variability within 10 m of the treated area. This variability was not correlated with VSI, such that the downwind transect S, which had the greatest levels of VSI, were the tallest plants, and when moving along the transects they converged on similar and less variable heights at 30 m and beyond. There were no controls included in the study. It is difficult to ascertain whether the effects on height reflect variable growth due to field conditions or if dicamba exposure played a role somehow. The distance estimates for 10%VSI were included in the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

Table E.8. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
N	<1[b]	<2[b]	<1[b]	<1[b]
E	<1[b]	<2[b]	<1[b]	<1[b]
S	<1[b]	<6[b]	<1[b]	<1[b]
W	<1[b]	<6[b]	<1[b]	<1[b]

- [a] distance estimated with logistic regression
- [b] distance estimated visually
- NA = Not applicable
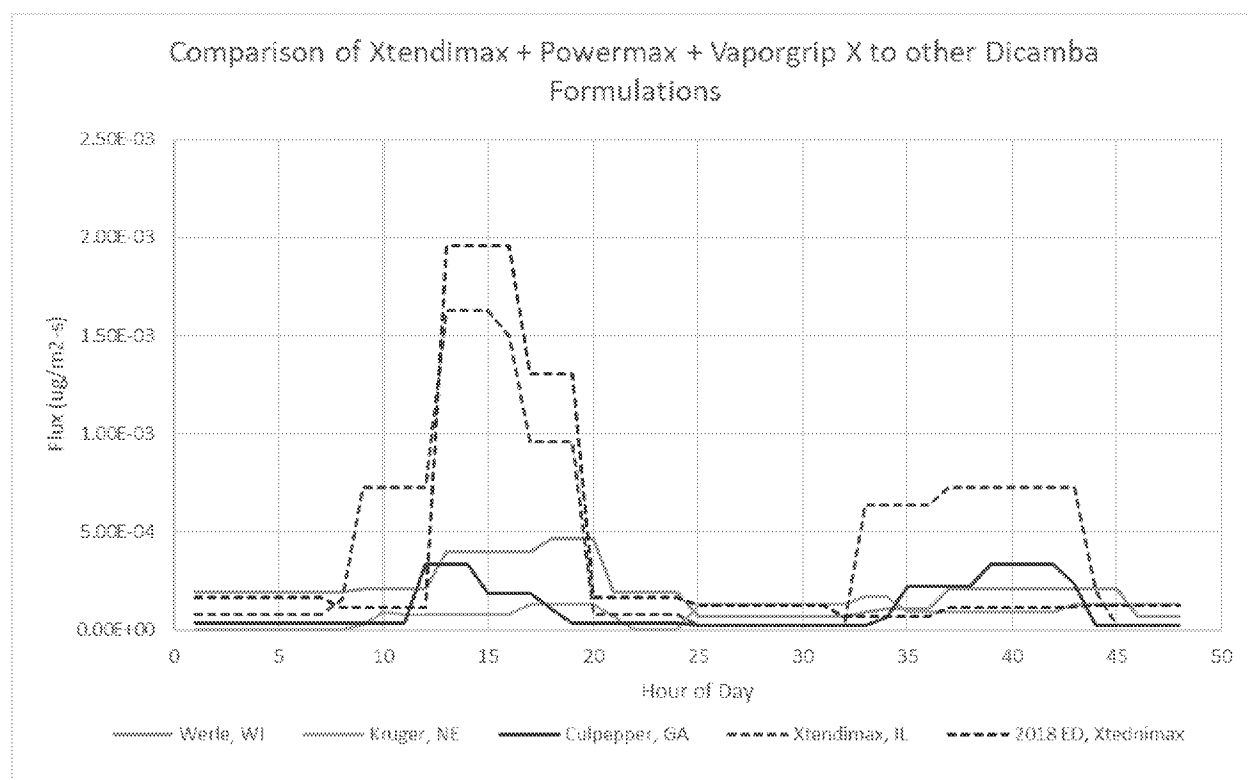
Figure E.22. Comparison of Flux Rates for Academic Studies Incorporating Vaporgrip X

2.1.3.2.2. University of Georgia

In 2019, Dr. Culpepper of the University of Georgia investigated the volatility of dicamba on an 8-acre field of dicamba-tolerant soybean in Georgia (MRID 51134102). The field was treated with XtendiMax with Vaporgrip, PowerMAX, Vaporgrip X, and Intact at rate of dicamba at 0.5 lbs ae/A on 9/10/2019 at 12:30 pm. Air samples were collected for 2.5 days using a mast at the center of the field at heights of 0.15, 0.3, 0.55, 0.9, and 1.5 m above the crop (crop height not specified). Spray drift samples were also collected along 2 transects in each of the cardinal directions from the field at distances of 2, 3, 4, 6, 8,

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10, 15, 23, 30, 40, and 60 meters from the edge of the field. Temperatures ranged from 19 – 36°C (66 – 97°F) during the study. Flux rates were derived using the aerodynamic and integrate horizontal flux methods. Flux rates were much lower than those presented prior to 2019 (**Figure E.22**). Maximum deposition value from spray drift along the transects was 1.43×10^{-3} lb ae/A. Based on deposition data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were less than 10 meters for all but one transect; one of the southern transects had deposition values exceeding the effects endpoint at 60 meters from the field.

2.1.3.2.3. University of Wisconsin

In 2019, Dr. Werle of the University of Wisconsin investigated the volatility of dicamba on a 7-acre field of dicamba-tolerant soybean in Wisconsin (MRID 51134102). The field was treated with XtendiMax, PowerMAX, Vaporgrip X, and Intact at rate of dicamba at 0.5 lbs ae/A on 7/14/2019 at 12:30 pm. Soybeans were at the V6 stage. The treated field was surrounded by dicamba nontolerant soybeans, designed to provide bioassay samples of potential dicamba damage. Transects in each of the cardinal directions were covered with tarps (16 x 3 m) to evaluate the impact of volatile dicamba emissions, with the tarps removed 60 minutes after application. Air samples were collected for 2.5 days using a mast at the center of the field at heights of 0.15, 0.3, 0.55, 0.9, and 1.5 m above the crop (crop height not specified). Spray drift samples were also collected along 2 transects in each of the cardinal directions from the field at distances of 2, 3, 4, 6, 8, 10, 15, 23, 30, 40, and 60 meters from the edge of the field. Temperatures ranged from 20 – 32°C (68 – 90°F) during the study. Flux rates were derived using the aerodynamic and integrate horizontal flux methods. Flux rates were much lower than those presented prior to 2019 (**Figure E.22**). Maximum deposition value from spray drift along the transects was 1.05×10^{-3} lb ae/A. Based on deposition data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were less than 6 meters for all transects.

The evaluation of VSI indicated that on 21 days after treatment (DAT) a significant distance to effect trend was observed with 35 %VSI at 0.8 m and less than 5 %VSI at 16 m for the downwind volatility (covered) transect (**Table E.9**). Notably, all volatility transects showed at least some VSI along most of the distance (1-15%) but significant trends were limited to the downwind side of the field (northern). The maximum distance to 10% VSI for the volatility exposure was estimated at 7.3 m based on logistic regression. Spray drift along the northern transect resulted in far greater VSI (70% at 0.8 m and not below 5% VSI until about 31m). The maximum distance of 10% VSI along the northern spray drift transect was estimated to be 24 m based on logistic regression.

Plant height was impacted significantly for the N transect but it appears only out to ~3 m. There is uncertainty regarding the evaluation of plant height because there were no designated controls for this study. Variability of plant height across transects and the field is such that the distance to height measures are less reliable than VSI based distances.

The transect data from this study were not used in the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

Table E.9. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
N	<3[b]	23.5	<3[b]	7.3[a]
E	<3[b]	2.6[-a]	<1[b]	1.0[a]
S	<1.5[b]	<1.5[b]	<1[b]	>2[b]
W	<1[b]	8.3[a]	<1[b]	<1.5[b]

- o   [a] distance estimated with logistic regression
- o   [b] distance estimated visually
- o   NA = Not applicable

2.1.3.2.4. University of Missouri

In 2019, Dr. Smeda of the University of Missouri investigated the volatility of dicamba on two 7-acre fields of dicamba-tolerant soybean in Millersburg Missouri (MRID 51134102). The fields were treated with XtendiMax with Vaporgrip, PowerMAX, Vaporgrip X, and Intact at rate of dicamba at 0.5 lbs ae/A on 7/23/2019 (application time not specified). Soybeans were at the V2-V3 stage. The treated field was surround by dicamba nontolerant soybeans, designed to provide bioassay samples of potential dicamba damage. Transects in each of the cardinal directions were covered with tarps (50 x 10 ft) to evaluate the impact of volatile dicamba emissions, with the tarps removed 35-50 minutes after application. Air samples were collected for 4 days using a mast at the center of the field at heights of 0.15, 0.3, 0.55, 0.9, and 1.5 m above the crop (crop height was 10 in). Spray drift samples were also collected along 2 transects in each of the cardinal directions from the field at distances of 2, 3, 4, 6, 8, 10, 15, 23, 30, 40, and 60 meters from the edge of the field. Temperature data were not available for the study. Flux rates could not be estimated, as the application time was unknown. Maximum deposition value from spray drift along the transects was 5.81×10^{-4} lb ae/A. Based on deposition data, distances to the vegetative vigor NOAEC for soybeans (2.6×10^{-4} lb ae/A) were less than 3 meters for all transects.

The plant effects portion of the study is of low utility for evaluating distance to effect evaluating the setbacks because of significant runoff related dicamba exposure. Runoff damaged plots often had similar reductions in height, but the magnitude of the reduction relative to unexposed plants is difficult to calculate given that there were no controls. The "North Block" treatment area had more significant signs of runoff damage. The spray drift transects in the downwind section of the field (S) show were not greatly impacted by runoff and had distances to 10%VSI estimated out to 19 m. The Southern study plot did not have a significant damage from runoff. VSI off of both southern transects (downwind) in excess of 10% out to 13 and 19 m. Observation of height along the worst hit transect suggests leveling off of damage at about 7m. The transect data from this study were not used in the analyses for evaluating the protectiveness of in-field application setbacks (Appendix F).

2.2. Engenia (VRA included)

2.2.1. Registrant Submitted Studies

2.2.1.1. Mississippi Study (MRID 51049003)

In June 2019, a field volatility study was conducted in Washington County, MS. The design included a test plot of approximately 23 acres (302 m by 302 m) of dicamba-tolerant soybeans, in the center of a 108-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on April 29, 2019 and replanted on May 24, 2019 as a result of seed damage due to heavy rain and flooding. The test plot was treated with Engenia, RoundUp PowerMAX, Intact (a drift reduction agent), and a proprietary approved VRA (buffering agent) on June 22, 2019 at 9:06 am. A single application of 0.5 lb dicamba/A was made using a Case SPX 3230 Patriot ground sprayer equipped with a 90 ft boom and 54 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 20 inches apart, at a boom height of 20 inches above the crop canopy (7.9 in). A spray drift test system consisted of three downwind transects (north side of field) perpendicular to the treated area, along with two transects on the east, west, and south sides of the treated field and transects along the diagonals. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 90 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 90 m and along the diagonals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Four upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application. At each study transect, plant heights and visual symptomology were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 90 m sample analyzed along the northern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 24.8-33.8°C (76.6-92.8°F), 20.1-36.8°C (68.2-98.2°F), and 57-95%, respectively. The pH of the tank mix was 5.59 prior to application.

EPA estimated flux rates from the study were lower than the maximum flux rates evaluated prior to 2019 (**Figure E.23**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 10.8 to 17.2 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 5.98 to 6.60 $\mu g/m^2$. It should be noted that the study evaluated prior to 2019 was conducted at a rate of 1.0 lb a.e./A, so the rates depicted in **Figure E.23** were divided by 2. Additionally, the current Engenia study used an approved VRA (buffering agent) designed to reduce volatility, so flux rates should be lower. Spray drift deposition from the edge of the field to reach the NOAEC for soybean (2.6×10^{-4} lb ae/A) was 14.2 m (11.4 to 16.1 m for the three transects) and 11.5 m (7.7 to 14.1 m for the two transects) in the downwind and left wind directions,

respectively. It should be noted that a heavy rain event (4.6 in) occurred on Day 2, between hours 23 and 29, which affected the volatility and plant effects measurements.
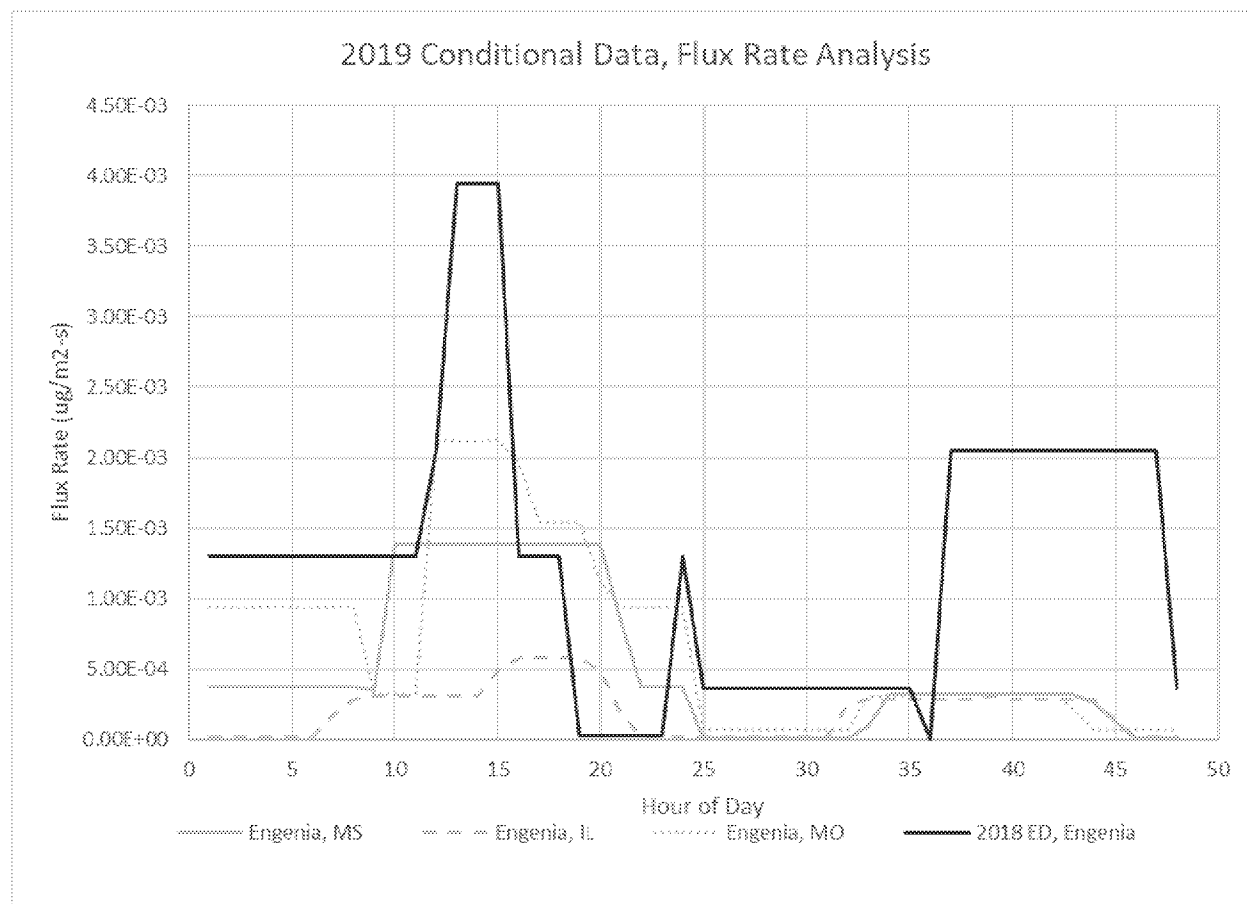
Figure E.23. Comparison of Flux Rates from Conditional Studies, Engenia

At 28 DAT, VSI 5 to 45% were reported in all volatility transects. A strong signal of distance to effect was observed for several volatility transects, with LWA, LWB, and RWB having 25-35% VSI at the furthest sampling distance (**Table E.10**). The downwind spray drift (uncovered) transects also had significant VSI with distance relationships. In the DWA, DWB, DWC, LWA, LWB, UWA, UWB, NE, SE and SW the distance to 10%VSI extending out to or beyond 60m (maximum 112 m).

Significant reductions in plant heights were also observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DW and LW transects, **Table E.10**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field due to responses of the condition of the field. Therefore, due to the non-uniformity of plant height across the field, there increased uncertainty in the distance estimates based on a 5% reduction relative to the control growth.

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Table E.1. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA	63.7[b]	91.0[b]	>3[d]	14.2[c]
DWB	42.5[b]	103.0[c]	>3[d]	12.6[c]
DWC	24.4[b]	60.5[b]	>20[d]	3.4[a]
LWA	>60[d]	87.3[a]	<3[d]	33.4[c]
LWB	21.3[a]	111.6[c]	<3[d]	30.1[c]
UWA	>60[d]	>60[d]	>20[d]	9.5[c]
UWB	>40[d]	>60[d]	>20[d]	3[d]
RWA	>5[d]	13.8[a]	>3[d]	<20[d]
RWB	>60[d]	2.2[a]	>20[d]	>20[d]
NE	25.7[a]	60.6[b]	NA	NA
NW	<10[d]	<3[d]	NA	NA
SE	>60[d]	>60[d]	NA	NA

[a] distance estimated with logistic regression
[b] distance estimated with polynomial regression
[c] distance estimated with linear regression
[d] distance estimated visually
NA = Not applicable

There are several concerns with the conduct and conditions of this study. In terms of the utility of the volatility transects (covered transects), a storm event occurred on Day 2, between hours 23 and 29, reducing the emissions from volatility. This reduction impacts the amount of material that the transects may have been exposed to via volatility. Distances based on vapor exposure alone (covered transects) will reflect plant responses to this lowered exposure and may underestimate distances under conditions of no rainfall.

A significant dicamba exposure event occurred prior to the application of dicamba to the field, as evidenced from VSI (5-10%) across all study transects, including controls, 1 day prior to application. The effects in controls may have continued to increase or a second exposure event following application added to the previous injury, by 15DAT VSI in the controls was 10% and persisted through 27DAT. This exposure event, having been observed over the entire non-dicamba tolerant crop, contributes to VSI that was observed in the transects used for defining distances above. The extent to which this may increase the distance estimates for 10% VSI cannot be discerned with the available information. The lack of a trend of VSI across the field on 1-day prior to application suggests an exposure route different from spray drift deposition.

Despite the compromised controls, the response across transects from this study were used in the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**). This is justified because the VSI indicated in the controls was reported after application and likely originated from the

application to the treated area in the study, since VSI response along the transects do not rely upon comparison to controls, there is not an impact on the distance to effect estimates.

2.2.1.2. Illinois Study (MRID 51049004)

In August 2019, a field volatility study was conducted in Shelby County, Illinois. The design included a test plot of approximately 19 acres (274 m by 274 m) of dicamba-tolerant soybeans, in the center of a 160-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on June 13, 2019 and replanted on July 16, 2019 as a result of seed damage due to significant precipitation. The test plot was treated with Engenia, RoundUp PowerMAX, Intact (a drift reduction agent), and a proprietary approved VRA (buffering agent) on August 7, 2019 at 14:18. A single application of 0.5 lb dicamba/A was made using a Rogator 1074 ground sprayer equipped with a 100 ft boom and 60 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 20 inches apart, at a boom height of 20 inches above the crop canopy (6.7 in). A spray drift test system consisted of three downwind transects (northeast side of field) perpendicular to the treated area, along with two transects on the southeast, southwest, and northwest sides of the treated field and transects along the cardinal directions. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 120 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 120 m and along the cardinals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Four upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application. Along each transect, plant height and VSI were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 120 m sample analyzed along the north eastern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 18.2-29.6°C (64.8-85.3°F), 20.1-39.6°C (68.2-103°F), and 54-98%, respectively. The pH of the tank mix was 5.50 prior to application. It should be noted that a heavy rainfall event (1.7 in) occurred 5 days after application.

EPA estimated flux rates from the study were lower than the maximum flux rates evaluated prior to 2019 (**Figure E.23**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 3.5 to 5.8 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 2.03 to 2.31 $\mu g/m^2$. It should be noted that the study evaluated prior to 2019 was conducted at a rate of 1.0 lb a.e./A, so the rates depicted in **Figure E.23** were divided by 2. Additionally, the current Engenia study used an approved VRA (buffering agent) designed to reduce volatility, so flux rates should be lower. Spray drift deposition from the edge

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of the field to reach the NOAEC for soybean (2.6×10^{-4} lb ae/A) was 12.3 m (6.5 to 15.4 m for each transect) in the downwind direction.

At 28 DAT, 10% VSI was restricted within 3 to 5 m from the edge of the treated area for all volatility transects (**Table E.11**). The downwind spray drift (uncovered) transects had a strong response of VSI with distance. In the DWA, DWB, DWC, and UWA the distance to 10%VSI went out as far as 29 to 52 m (**Table E.11**).

Significant reductions in plant heights were also observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DWA, DWB and DWC transects, **Table E.11**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field due to responses of the condition of the field, and these differences grew more severe as the study progressed. Many of the transects that did not show signs of dicamba exposure (lacking in VSI) had measured heights that were significantly different from the controls. Therefore, due to the non-uniformity of plant height across the field, there increased uncertainty in the distance estimates based on a 5% reduction relative to the control growth. The impact of dicamba specific reductions in plant height are confounded by field conditions and differential growth rates across the non-tolerant soybean crop such that reduction of expected plant height (i.e., 5% reduction of mean control height) as a result of dicamba exposure is likely masked by the variable nature of conditions in the field.

Table E.11. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA	5[b]	34[d]	<3[c]	<3[c]
DWB	32[b]	52[d]	<3[c]	<3[c]
DWC	36[b]	50[d]	<3[c]	<3[c]
LWA	<3[c]	<3[c]	<10[c]	<3[c]
LWB	<50[c]	<3[c]	<20[c]	<3[c]
UWA[e]	<20[c]	29[b]	<3[c]	<3[c]
UWB	<3[c]	<3[c]	<3[c]	<3[c]
RWA	<60[c]	<3[c]	<3[c]	<3[c]
RWB	<3[c]	<3[c]	<3[c]	<5[c]
N	125[a]	<3[c]	NA	NA
S	<3[c]	<3[c]	NA	NA
E	<20[c]	<3[c]	NA	NA
W	<3[c]	<3[c]	NA	NA

[a] distance estimated with linear regression
[b] distance estimated with logistic regression
[c] distance estimated visually
[d] distance estimated with polynomial regression
[e] transect impacted by runoff exposure
NA = Not applicable

There are several concerns with the conduct and conditions of this study. In terms of the utility of the volatility transects (covered transects), a storm event occurred within 24 hrs of application (day 2), reducing the emissions from volatility. This reduction impacts the amount of material that the transects may have been exposed to. Distances based on vapor exposure alone (covered transects) will reflect plant responses to this lowered exposure and may underestimate distances under conditions of no rainfall.

While there was presence of dicamba detected in two pre-application air samples, no VSI was reported for control plots or transects the day prior to application. VSI that was observed on 14 DAT showed strong signal of distance to effect, such that exposure related to that injury most likely came from the treatment of the test plot. Therefore, the pre-application exposure does not confound the interpretation of the VSI or plant height estimates.

The transect data from this study were used in the analyses for evaluating the protectiveness of in-field application setbacks (Appendix F).

2.2.1.3. Missouri Study (MRID 51049002)

In September 2019, a field volatility study was conducted in New Madrid County, Missouri. The design included a test plot of approximately 19 acres (274 m by 274 m) of dicamba tolerant soybean, in the center of a 150-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on August 1, 2019 and replanted on August 14, 2019 as a result of low emergence due to heavy rain on August 3rd and 6th. was treated with Engenia, RoundUp PowerMAX, Intact (a drift reduction agent), and a proprietary approved VRA (buffering agent) on September 12, 2019 at 11:15. A single application of 0.5 lb dicamba/A was made using a John Deere R4030 ground sprayer equipped with a 90 ft boom and 73 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 15 inches apart, at a boom height of 20 inches above the crop canopy (7.9 in). A spray drift test system consisted of three downwind transects (northeastern side of field) perpendicular to the treated area, along with two transects on the southeast, southwest, and northwest sides of the treated field and transects along the cardinals. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 120 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 120 m and along the cardinals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Eight upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application. Along each transect, plant height and VSI were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 120 m sample analyzed along the northeastern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 24.1-46.3°C (75.4-115°F), 20.1-36.8°C (68.2-98.2°F), and 46-94%, respectively. The pH of the tank mix was 5.50 prior to application.

EPA estimated flux rates from the study were lower than the maximum flux rates evaluated prior to 2019 (**Figure E.23**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 15.8 to 25.9 ng/m^3 from the edge of the treated field and the maximum 24-hour average total deposition ranged from 8.56 to 9.93 µg/m^2. It should be noted that the study conducted prior to 2019 was conducted at a rate of 1.0 lb a.e./A, so the rates depicted in **Figure E.23** were divided by 2. Additionally, the current Engenia study used an approved VRA (buffering agent) designed to reduce volatility, so flux rates should be lower. Spray drift deposition from the edge of the field to reach NOAEC for soybean (2.6x10^{-4} lb ae/A) was 9.98 m (7.07 to 15.64 m for the three transects) and 10.24 m (10.23 to 10.25 m for the two transects) in the downwind and left wind directions, respectively.

At 28 DAT, VSI $\leq$ 10% were observed for the entire 20m length of all volatility transects. All spray drift (uncovered) transects also showed $\leq$ 10% VSI for the entirety of the transects with strong distance to effect trends for several transects (**Table E.12**). Significant reductions in plant heights were also observed to have strong distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., DWA, DWB, DWC, LWA, and LWB transects, **Table E.12**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field due to responses of the condition of the field, and these differences grew more severe as the study progressed. Therefore, due to the non-uniformity of plant height across the field, there increased uncertainty in the distance estimates based on a 5% reduction relative to the control growth. The impact of dicamba specific reductions in plant height are confounded by field conditions and differential growth rates across the non-tolerant soybean crop such that reduction of expected plant height (i.e., 5% reduction of mean control height) as a result of dicamba exposure is likely masked by the variable nature of conditions in the field.

Table E.12. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA	>120[a]	34[b]	20[a]	>20[a]
DWB	34[b]	>120[a]	20[a]	>20[a]
DWC	18[a]	>120[a]	20[a]	>20[a]
LWA	>60[a]	>60[a]	<20[a]	>20[a]
LWB	>60[a]	>60[a]	>20[a]	>20[a]
UWA	<50[a]	<5[a]	>3[a]	>20[a]
UWB	<50[a]	<20[a]	>3[a]	>20[a]
RWA	>3[a]	>120[a]	>3[a]	>20[a]

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Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
RWB	>3[a]	>120[a]	>3[a]	>20[a]
N	>3[a]	>60[a]	NA	NA
S	>3[a]	17[b]	NA	NA
E	>60[a]	44[b]	NA	NA
W	>60[a]	40[a]	NA	NA

[a] distance estimated visually
[b] distance estimated with logistic regression
NA = Not applicable

There are several concerns with the conduct and conditions of this study. Notably, this study was conducted late in the summer with plants that were planted in August and final assessment of effects being observed in late September. It is unclear how this late season study may relate to potential reductions of plant growth and manifestation of VSI when exposed during the typical vegetative growing season (May-July).

A significant dicamba exposure event occurred after application of dicamba to the test plot. Evidenced from VSI (15-20%) across all control plots 14 days after treatment. It is unclear if the damage to the controls was related to the treatment in the study or from some unknown source; however, VSI was observed along every covered and uncovered transect, with greatest effect adjacent to the field and in some cases (along longest transects 60-120 m) declined to control levels of VSI (15-20% VSI) The VSI observed on 28DAT was consistent with that of the 14DAT observations.

The transect data from this study were not used in the analyses for establishing evaluating the protectiveness of in-field application setbacks (**Appendix F**).

2.3. Tavium

2.3.1. Registrant Submitted Studies

2.3.1.1. Nebraska Study (MRID 50102118)

As part of its new registration, a field study was conducted in York, NE, in 2016. Two 640 feet x 640 feet (9.4 A) plots, separated by 1000 feet, of dicamba-tolerant soybean were treated on July 12th at 8:53 am and July 14th at 10:30 am with Tavium with VaporGrip at a rate of 0.5 lb a.e/A of dicamba and 1.0 lb a.e./A of s-metolachlor. A Hagie boom sprayer was used for broadcast application at both plots, with the spray boom fitted with 32 flat fan Turbo Teejet® Induction (TTI) 11004 nozzles and 50 mesh screens. Nozzles were evenly spaced 30 inches apart, providing an 80-foot swath width. The boom height was set ca. 30 inches above the soybean canopy. Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 17.6-29.3°C (63.7-84.7°F), 21.8-29.1°C (71.2-84.4°F), and 31-100%, respectively, for Site 1 and 15.7-29.1°C (60.3-84.4°F), 21.1-27.3°C (70.0-81.1°F), and 28-98%, respectively, for Site 2. The pH of the soil was 6.1-6.6. EPA estimated flux rates from the study were comparable to the maximum flux rates evaluated prior to 2019, with air modeling of an 10-acre field

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indicating that, at 5 m from the field, the maximum 24-hr air concentration was 2.99 ng/m^3 from the edge of the treated field and the maximum 24-hour average dry deposition was 1.75 and 0.86 ng/m^2 for fields 1 and 2, respectively, and the maximum 24-hour average total deposition ranged from 4.61x10^{-7} to 7.22x10^{-6} lb/A at 5 m from the edge of the field.

2.3.1.2. Mississippi Study (MRID 50958203)

In July 2019, a field volatility study was conducted in Washington County, MS. The design included a test plot of approximately 20 acres (302 m by 268 m) of dicamba-tolerant soybeans, in the center of a 105-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on July 5, 2019. The test plot was treated with Tavium with VaporGrip, RoundUp PowerMAX II, and Intact (a drift reduction agent) on July 29, 2019 at 8:47. A single application of 0.5 lb dicamba/A was made using a Case Patriot 3230 ground sprayer equipped with a 80 ft boom and 48 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 20 inches apart, at a boom height of 20 inches above the crop canopy (9 in). A spray drift test system consisted of three downwind transects (northeastern side of field) perpendicular to the treated area, along with two transects on the southeast, southwest, and northwest sides of the treated field and transects along the cardinals. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 90 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study, although samples collected on Days 6 and 7 were not analyzed due to rainfall. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 90 m and along the cardinals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Five upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 51 minutes after application. At each study transect, plant heights and visual symptomology were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 90 m sample analyzed along the northeastern transects).
Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 23.06-32.68°C (73.51-90.8°F), 26.2-41.01°C (79.16-106°F), and 56-94%, respectively. The pH of the tank mix was 5.03.

Flux rates estimated from the study were comparable to the maximum XtendiMax with Vaporgrip flux rates evaluated prior to 2019 (**Figure E.24**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the maximum 24-hr air concentration was 2.99 ng/m^3 from the edge of the treated field and the maximum 24-hour average dry deposition was 1.11 μg/m^2. Spray drift deposition from the edge of the field to reach the NOAEC for soybean (2.6x10^{-4} lb ae/A) was 6.4 (4.1 to 10.2 m in the three transects) and 3.4 m (1.6 to 5.8 m in the two transects) in the northeast and southeast directions, respectively.

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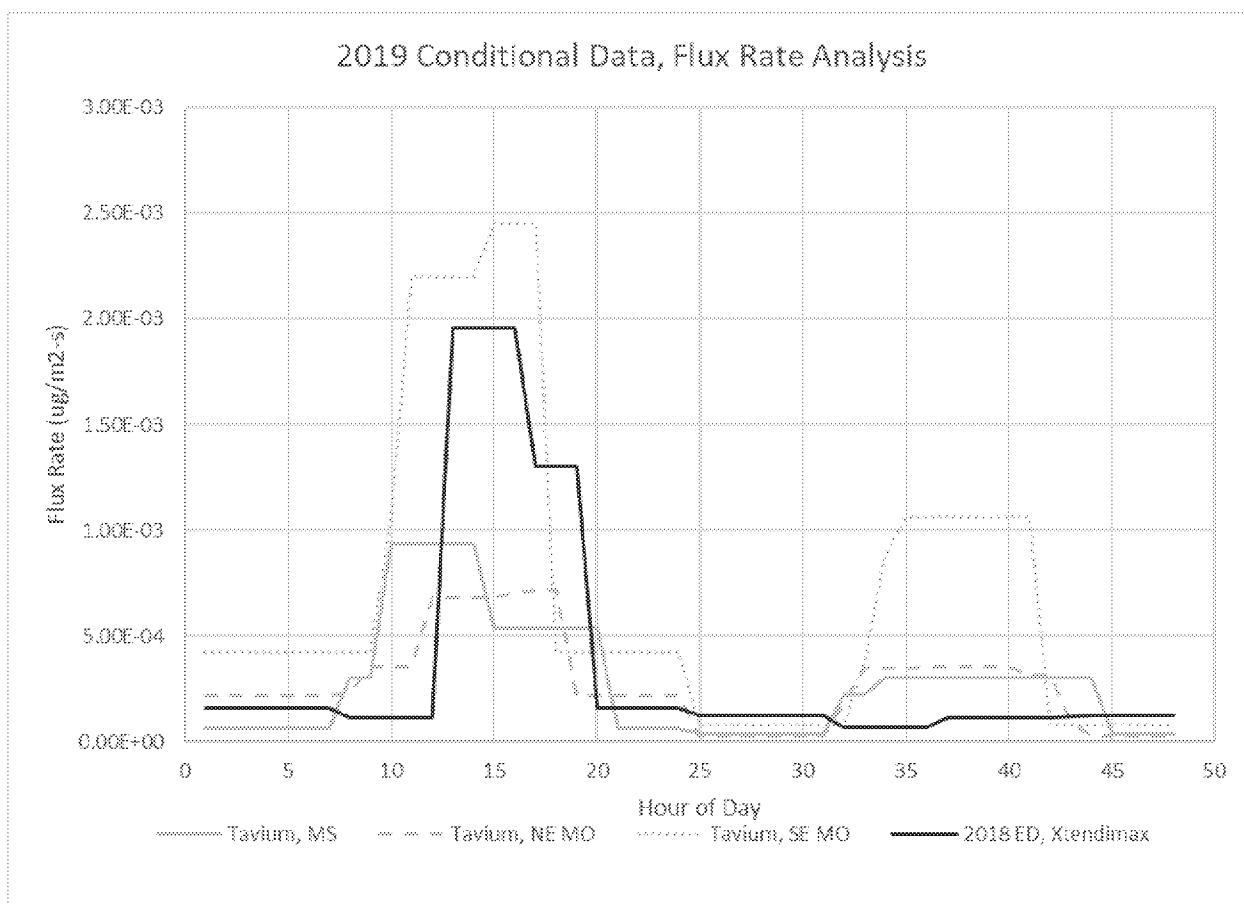
Figure E.24. Comparison of Flux Rates from Conditional Studies, Tavium

At 28 DAT, VSI 5 to 15% were reported in all volatility transects and showed more damage adjacent to the field than further away (**Table E.13**). All volatility transects except NE2 had distances measures of 10%VSI within the 20 m transect length, NE2 reported 10-15% along the entire transect. The downwind spray drift (uncovered) transects also had significant VSI with distance relationships. In the EE, NE, and SE transects with distance to 10% VSI extending out to or beyond 36m (maximum 142 m).

Significant reductions in plant heights were also observed to have distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., EE, and NE transects, **Table E.13**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field due to responses of the condition of the field. Therefore, due to the non-uniformity of plant height across the field, there increased uncertainty in the distance estimates based on a 5% reduction relative to the control growth. The impact of dicamba specific reductions in plant height are confounded by field conditions and differential growth rates across the non-tolerant soybean crop such that reduction of expected plant height (i.e., 5% reduction of mean control height) as a result of dicamba exposure is likely masked by the variable nature of conditions in the field.

Table E.13. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
Drift EE	<20[b]	55.3a	NA	NA
Drift NE1	10.2[a]	47.0a	<3 [b]	<20[b]
Drift NE2	28.9[c]	141.6[a]	<3 [b]	>20[b]
Drift NE3	13.6 [c]	119.1[a]	<3 [b]	<20[b]
Drift NN	<3 [b]	<3 [b]	NA	NA
Drift NW1	<20 [b]	<20 [b]	<3 [b]	<10[b]
Drift NW2	<3 [b]	<20 [b]	<3 [b]	<10[b]
Drift SE1	<20 [b]	36.7[a]	<20[b]	<5[b]
Drift SE2	<3 [b]	35.8[a]	<3 [b]	<10[b]
Drift SS	>60 [b]	<3 [b]	NA	NA
Drift SW1	>60 [b]	<10 [b]	NA	NA
Drift SW2	<3 [b]	<10 [b]	<3 [b]	<5[b]
Drift WW	>60 [b]	<10 [b]	NA	NA

[a] distance estimated with logistic regression
[b] distance estimated visually
[c] distance estimated with polynomial regression
NA = Not applicable

There are several concerns with the conduct and conditions of this study. Notably, significant precipitation between planting and application led to ponding in parts of the study area, which resulted in stunted soybeans and areas of low plant population within the test site.

A significant dicamba exposure event occurred after application of dicamba to the test plot. Evidenced from VSI (5%) across all control plots 14 days after treatment. It is unclear if the damage to the controls was related to the treatment in the study or from some unknown source; however, VSI was observed along every covered and uncovered transect, with greatest effect adjacent to the field and in some cases (along longest transects 60-90 m) declined to control levels of VSI (5% VSI) The VSI observed on 28DAT was consistent with that of the 14DAT observations.

The transect data from this study were not used in the analyses for evaluating the protectiveness of in-field application setbacks (**Appendix F**).

2.3.1.3. Northeast Missouri Study (MRID 50958201)

In July 2019, a field volatility study was conducted in Ralls County, Missouri. The design included a test plot of approximately 19 acres (283 m by 271 m) of dicamba-tolerant soybeans, in the center of a 160-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on June 30, 2019. The test plot was treated with Tavium with

VaporGrip, RoundUp PowerMAX, and Intact (a drift reduction agent) on July 24, 2019 at 10:50. A single application of 0.5 lb dicamba/A was made using a John Deere R4030 ground sprayer equipped with a 99 ft boom and 79 Turbo TeeJet® Induction (TTI) 11004 nozzles, spaced 15 inches apart, at a boom height of 20 inches above the crop canopy (10 in). A spray drift test system consisted of three downwind transects (south side of field) perpendicular to the treated area, along with two transects on the east, west, and north sides of the treated field and transects along the diagonal directions. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 90 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented. Lastly, a plant effects test system, including a uniform stand planted with soybeans tolerant to glyphosate, but not dicamba (non-dicamba tolerant soybeans), was implemented surrounding the treated areas. Plant effect transects were positioned perpendicular to the treated area to a maximum distance of 90 m and along the cardinals of the field to evaluate volatility (covered transects) and spray drift (uncovered transects) exposure. Four upwind control areas were also identified and evaluated for plant height. Plant effects from volatility were evaluated by covering approximately 20 m by 3 m of non-tolerant soybean crop along the volatility transects during the application period to prevent exposure via spray drift. The covers were scheduled to be removed approximately 30 minutes after application. Along each transect, plant height and VSI were measured 0, 14 and 28 days after treatment (DAT; post-application) on ten plants at each distance along each transect distance (3, 5, 10, 20, 40, 50, and 60 m, with a 90 m sample analyzed along the north eastern transects).

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 4.34-28.8°C (39.8-83.8°F), 15.9-33.4°C (60.6-92.1°F), and 47-100%, respectively. The pH of the tank mix was 4.9 before the application.

Flux rates estimated from the study were comparable to the maximum XtendiMax with Vaporgrip flux rates evaluated prior to 2019 (**Figure E.24**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 2.3 to 5.9 ng/m^3 from the edge of the treated field and the maximum 24-hour average dry deposition ranged from 0.6 to 1.17 µg/m^2. Spray drift deposition from the edge of the field to reach the NOAEC for soybean (2.6x10^{-4} lb ae/A) was 2.8 m (3.1 to 6.3 m for the three transects) in the downwind direction.

At 28 DAT, 5% VSI were reported in several volatility transects, only RWA had 10%VSI at 3m from the treated area (**Table E.14**). The downwind spray drift (uncovered) transects had significant VSI with distance relationships along several transects. In the DW, RW and SE transects distance to 10%VSI extended out to or beyond 16m (maximum 39 m).

Significant reductions in plant heights were also observed to have distance to effect patterns (i.e., more reduction closer to the treated area) in areas downwind of the treated area (e.g., EE, and NE transects, **Table E.14**). Although the study author attempted to minimize variability by selecting plot distances that had plants of similar height at the start of the study, plant height differed across the field due to responses of the condition of the field. Therefore, due to the non-uniformity of plant height across the field, there increased uncertainty in the distance estimates based on a 5% reduction relative to the control growth. The impact of dicamba specific reductions in plant height are confounded by field conditions and differential growth rates across the non-tolerant soybean crop such that reduction of

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expected plant height (i.e., 5% reduction of mean control height) as a result of dicamba exposure is likely masked by the variable nature of conditions in the field.

Table E.14. Estimated distances to regulatory threshold responses for reductions in plant height and visible signs of injury.

Exposure Pathway	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
Transect	Distance to 5% Height (meters)	Distance to 10% VSI (meters)	Distance to 5% Height (meters)	Distance to 10% VSI (meters)
DWA Drift	>90[b]	18.0[a]	<3 [b]	<3 [b]
DWB Drift	107.4[a]	29.6[a]	<3 [b]	<3 [b]
DWC Drift	42.7[a]	39.3[b]	<3 [b]	<3 [b]
LWA Drift	<3 [b]	<3 [b]	<3 [b]	<3 [b]
LWB Drift	<3 [b]	<5	<3 [b]	<3 [b]
NE Drift	<3 [b]	<3 [b]	NA	NA
NW Drift	<3 [b]	<3 [b]	NA	NA
RWA Drift	119.7[c]	15.5[a]	<20[b]	<3 [b]
RWB Drift	105.7[c]	16.7[a]	<3 [b]	<3 [b]
SE Drift	67.6[a]	31.5[a]	NA	NA
SW Drift	>90[b]	<3 [b]	NA	NA
UWA Drift	<40[b]	<3 [b]	<3 [b]	<3 [b]
UWB Drift	<20[b]	<3 [b]	<3 [b]	<3 [b]

[a] distance estimated with logistic regression
[b] distance estimated visually
[c] distance estimated with polynomial regression
NA = Not applicable

There are concerns with the conduct and conditions of this study. Notably, significant precipitation between planting and application led to ponding in parts of the study area, which resulted in stunted soybeans and areas of low plant population and highly variable plant heights within the test site. Distance to effect estimates for height extend much further than the 10% VSI estimates suggesting that the observed plant height effects are likely consequences of field conditions rather than dicamba exposure. The plant height transect data from this study were not used in the analyses evaluating the protectiveness of in-field application setbacks.

1.1.1.1. Bootheel Missouri Study (MRID 50958202)

In September 2019, a field volatility study was conducted in Scott County, Missouri. The design included a test plot of approximately 18 acres d application setbacks; however, since VSI is a direct measure of a plant's response to a dicamba exposure, the estimated VSI distances were used in the estimation process (**Appendix F**). The design included a test plot of approximately 19 acres (256 m by 288 m) of dicamba tolerant soybean, in the center of a 140-acre agricultural field planted with non-tolerant soybean. The test plot and surrounding buffer zone were planted in non-tolerant soybean on July 8, 2019 and replanted on August 9, 2019 due to injuries symptomatic of dicamba injury. On August 26,

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2019, the non-dicamba tolerant soybeans were inspected and injuries symptomatic of dicamba injury were observed, so the plant effects portion of the study was not conducted. The test plot was treated with Tavium with VaporGrip, RoundUp PowerMAX, and Intact (a drift reduction agent) on September 9, 2019 at 9:38. A single application of 0.5 lb dicamba/A was made using a RoGator 1100C ground sprayer equipped with a 119 ft boom and 143 Turbo TeeJet® Induction (TTI) 11004-VP nozzles, spaced 10 inches apart, at a boom height of 36 inches above the crop canopy (12 in). According to the label, applications are to be made "no more than 24 inches above the target." A spray drift test system consisted of three downwind transects (northern side of field) perpendicular to the treated area, along with two transects on the east, south, and west sides of the treated field. Deposition collectors (Whatman #1 15 cm diameter filter papers) were placed on all transects at 3, 5, 10, 20, 40, 50, and 60 m away from the field, with additional collectors at 90 m away from the field on the downwind transects. Deposition collectors were secured to carboard squares and attached to a horizontal plastic platform at crop height. Deposition samples were collected for the 7 days of the field study. A volatilization test system, including both in-field and off-field (perimeter) sampling locations as well as flux meteorological stations for the test plot, was also implemented.

Air temperatures, surface soil temperatures, and relative humidity on the day of application ranged from 18.5-35.3°C (65.3-95.5°F), 20.1-37.5°C (68.2-99.5°F), and 48-100%, respectively. The pH of the tank mix was 4.8.

Flux rates estimated from the study were comparable to the maximum XtendiMax with Vaporgrip flux rates evaluated prior to 2019 (**Figure E.24**), with air modeling of an 80-acre field indicating that, at 5 m from the field, the 95th percentile 24-hr air concentrations ranged from 4.7 to 10 ng/m^3 from the edge of the treated field and the maximum 24-hour average dry deposition was 2.04 μg/m^2. Spray drift deposition from the edge of the field to reach NOAEC for soybean (2.6x10^{-4} lb ae/A) was 3.5 (1 to 4.8 m for the three transects) and 10.6 m (4.5 to 17 m for the two transects) in the downwind (north) and right wind (west) directions, respectively.

There are concerns with the conduct and conditions of this study. The authors indicate that 2 separate dicamba exposure events had occurred prior to application in the test plot. These events resulted in VSI across the entire non-tolerant soybean crop therefore they could not complete the plant portion of the study design. Importantly, the dicamba exposure events indicate that damage occurred across distances in excess of 1400 ft (the radius of the center pivot spanning the test area) and are far greater distances than the labeled in-field setbacks. No investigation of the two incidents were provided to EPA, as a result EPA cannot determine what routes of exposure or use sites were potentially implicated in the incidents.

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Appendix F. Establishment of the Distance to Effect – Probability Analyses

For this assessment, considering both spray drift and volatile drift exposure to terrestrial plants in the off-site areas, EPA developed a probabilistic, distributional approach for determining a reasonable upper bound estimate for the distance from the field to plant effects, combining the effects-to-distance data from all of the reliable field studies (see **Appendix E**).

EPA created separate probability distributions for spray drift + volatility (informs the in-field downwind setback) and volatility alone (informs the in-field omni-directional setback) following variable and data sets:

Spray drift-related distance to plant effects:

5. Distance from the treatment field edge to a point related to direct estimate of 5% height for all field spray drift + volatility (uncovered) transects reporting height
6. Distance from the treatment field edge to a point related to direct estimate of 10% VSI for all field spray drift + volatility (uncovered) transects reporting VSI.

Volatile emissions-related distance to plant effects:

1. Distance from the treatment field edge to a point related to direct estimate of 5% height for all field volatility (covered) transects reporting height.
2. Distance from the treatment field edge to a point related to direct estimate of 10% VSI for all field volatility (covered) transects reporting VSI.

EPA used Crystal Ball add-in software to Excel to fit distribution functions to the data sets. Crystal Ball enables the user to fit various probability distribution functions to a data set and then sample those distributions thousands of times using Monte Carlo probabilistic algorithms to test the extent to which the selected distributions tend to over or underestimate any segment of the distribution of the variable. Because EPA is interested in reasonable upper bound estimates (protective) for the distance to effects analysis, the Agency selected a distribution to fit to the data that would be a more accurate representation of the dispersion of data at the upper limits of the distribution. The fit was considered reasonable if when comparing the data, the fit distribution and the distribution of randomly sampled values were consistent.

1. Summary of Distance Estimates for Evaluating Required In-field Setbacks on the Labels:

Table F.1 provides the 90th and 95th percentile distances for the uncovered and covered transects. The Crystal Ball output for each distribution is provided at the end of this appendix. EPA found good agreement between data, fit distribution, and resampled distribution in all cases up through the 95th percentile. The results imply that dicamba can cause plant response in excess of 10% VSI as far as 240-310 ft (for downwind spray drift + volatility) and 110-160 ft (omnidirectional volatility) from the treated field. As described in **Appendix E and D**, there is greater uncertainty in the distances estimated with direct measure of plant height because plant height is affected by other conditions in the field (e.g., soil moisture, topography, insolation) and there is a smaller dataset available for plant height (**Appendix E**). As a result, distance estimates for height are less robust than those that consider the measurement of VSI. In addition to having lower environmental influence than height, the use of the measurement of VSI allows for the inclusion of a greater geographic and temporal representation because there are several studies that did not measure plant height.

Table F.1. Estimated distance to effects thresholds for protecting growth and reproduction of sensitive vegetation from spray drift and volatility based dicamba exposure pathways.

Probability assuming best fit distribution	Spray Drift + Volatility (uncovered transects)		Volatility (covered transects)	
	10% VSI (N=105)	5% plant height (N=73)	10% VSI (N=76)	5% plant height (N=41)
95th percentile distance	310	330	160	66[1]
90th percentile distance	240	240	110	46

[1] Given the variability of the data for plant height, EPA concluded that the distances to 10% VSI represent a more robust and environmentally representative measure of distance to effect.

Figure F.1 shows the relationship of the Crystal Ball predicted percentiles (blue curve) for the uncovered transects (spray drift + volatility) as they compare to the empirical measurements of plant distance to 10%VSI for different tested dicamba products. The vertical lines represent the 90th and 95th percentiles of the distribution corresponding to the 240 and 310 ft in-field downwind spray drift setbacks on the labels.
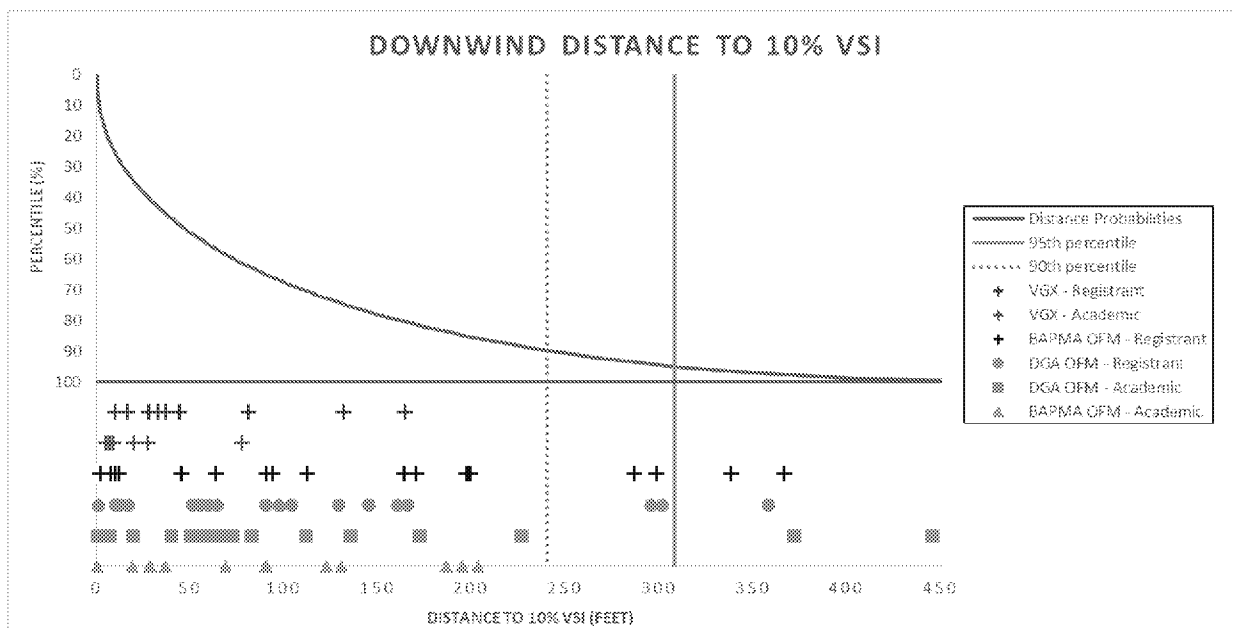
Figure F.1. Distribution of off-field distance to 10% VSI estimated by probabilistic modeling based on empirical measures of VSI from uncovered transects in in OFM studies (shown below the curve with symbols). Vertical orange lines provide 90th and 95th percentile distance estimates.

Figure F.2 shows the relationship of the Crystal Ball predicted percentiles (blue curve) for the covered transects (volatility) as they compare to the empirical measurements of plant distance to 10%VSI for different tested dicamba products. The vertical lines represent the labeled in-field 57ft omnidirectional volatility setback and the 95th percentiles of the distribution (160 ft).
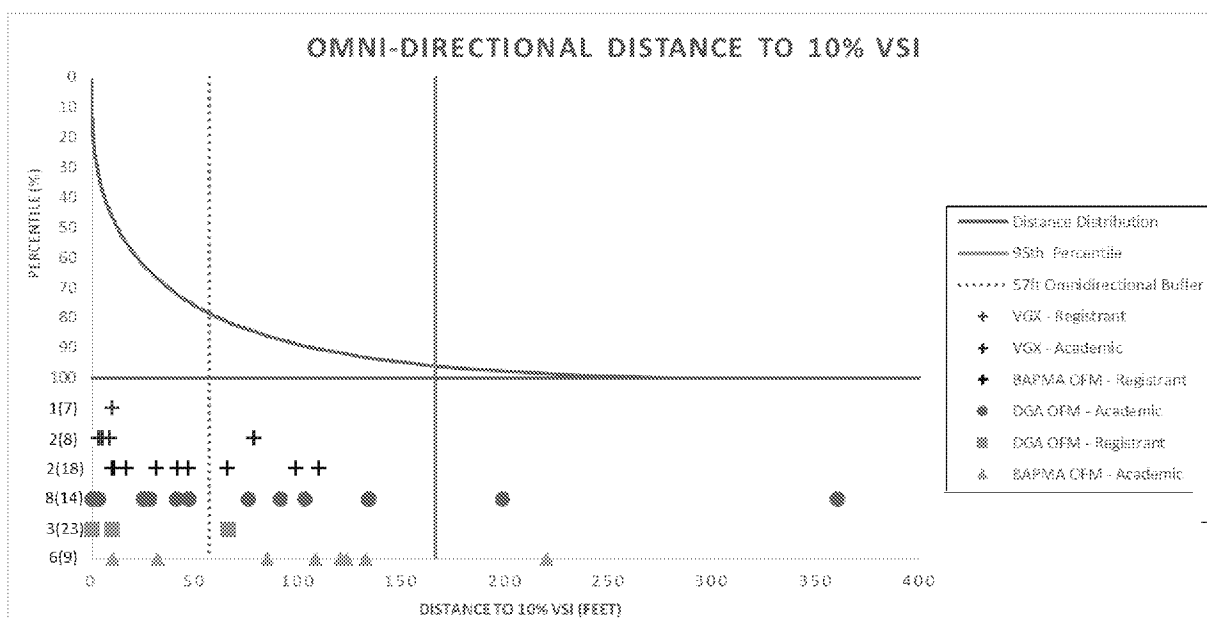
Figure F.2. Distribution of off-field distance to 10% VSI estimated by probabilistic modeling based on empirical measures of VSI from covered transects in in OFM studies (shown below the curve with symbols). Vertical orange lines provide in-field 57 ft omnidirectional volatile emissions setback on the labels and 95th percentile distance estimates.

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2. Evaluation of the Potential Impact of Drift Reducing Agents (DRAs) on the Distance to Effect Analysis Under Field Conditions

In evaluating the impacts of spray drift plus volatility to nontarget plants, EPA estimated the distance to 10% VSI (see discussion in **Appendix D**), using the available Off-Field Movement (OFM) studies submitted by the registrants and academia (**Appendix E**). When determining the off-field distance to effect (**Section F.1**), EPA did not separate out the data based on whether or not a drift reducing agent or volatility reducing agent was included in the tank mix, as the variety of tank mix partners (i.e., with or without glyphosate) and nozzles was limited. That being said, the majority of the studies (88%) included a drift reducing agent, Intact®, and had mixed results on reducing drift in the field (**Table F.2**). Studies including Intact® had the largest as well as the smallest distances to effect (**Tables F.4 and F.6**). As such, EPA concludes that the inclusion of a drift reducing agent into the tank mix does not have a significant impact on reducing the distance to effect for 10% VSI when considering the full body of information under field conditions.

Tables F.3 to F.6 provide distances estimated for each study/transect grouped by product and presence or absence of DRAs. Given that these results reflect those obtained from field studies, where meteorological (i.e., wind speed, wind direction, temperature and relative humidity, and application (i.e., boom speed, release height, nozzle configurations) conditions varied from site to site during the applications, it is difficult to ascertain the impact of the DRA alone. Laboratory studies in controlled environments would allow for the elimination of site-specific variables and a complete evaluation of the extent of any drift reduction that adding a DRA to a tank mix would provide.

Table F.2. Summary of available dicamba product Off-Field Movement (OFM) data, inclusion or exclusion of a DRA, and distance summaries.

Product	DRA		No DRA		Total
	Number of transects (% of Total)	Maximum (average) Distance (m)	Number of transects (% of Total)	Maximum (average) Distance (m)	Number of transects
Engenia	26 (67%)	112 (37)	13 (33%)	62 (28)	39
XtendiMax	62 (94%)	136 (22)	4 (6%)	69 (41)	66
Total	88 (84%)	136 (26)	17 (16%)	69 (31)	105

Table F.3. Engenia product OFM studies that did not include DRAs

Study	Date	Transect	Distance (m)
NE "all injury Data 4WAT"	*2017	Primary + Secondary	61.95
Jones	7/6/2016	N	59.38
Jones	7/6/2016	NE	56.81
AR "all injury Data 4WAT"	*2017	Primary + Secondary	39.74
Jones	7/6/2016	E	37.29
MO "all injury Data 4WAT"	*2017	Primary + Secondary	27.60
TN "all injury Data 4WAT"	*2017	Primary + Secondary	27.46
Jones	7/6/2016	SE	20.97
Jones	7/6/2016	NW	11.09
IN "all injury Data 4WAT"	*2017	Primary + Secondary	8.63
Jones	7/6/2016	S	8.56

Study	Date	Transect	Distance (m)
Jones	7/6/2016	W	5.69
Jones	7/6/2016	SW	0.0018

Table F.4. Engenia product OFM studies that included DRAs

Study	Date	Transect	Distance (m)
MRID 51049003	2019-MS	LWB	111.61
MRID 51049003	2019-MS	DWB	103.04
MRID 51049003	2019-MS	DWA	91.00
MRID 51049003	2019-MS	LWA	87.33
MRID 51049003	2019-MS	NE	60.64
MRID 51049003	2019-MS	DWC	60.54
MRID 51049003	2019-MS	UWA	> 60
MRID 51049003	2019-MS	UWB	> 60
MRID 51049003	2019-MS	SE	> 60
MRID 51049003	2019-MS	SW	> 60
MRID 51049004	2019-IL	DWB	51.88
MRID 51049004	2019-IL	DWC	49.92
MRID 51049004	2019-IL	DWA	34.21
MRID 51049004	2019-IL	UWA	28.62
MRID 51049003	2019-MS	RWA	13.77
MRID 51049003	2019-MS	RWB	2.19
MRID 51049004	2019-IL	N	3
MRID 51049003	2019-MS	NW	< 3
MRID 51049004	2019-IL	UWB	< 3
MRID 51049004	2019-IL	RWA	< 3
MRID 51049004	2019-IL	RWB	< 3
MRID 51049004	2019-IL	S	< 3
MRID 51049004	2019-IL	E	< 3
MRID 51049004	2019-IL	W	< 3
MRID 51049004	2019-IL	LWA	0.49
MRID 51049004	2019-IL	LWB	0.61

Table F.5. XtendiMax product OFM studies that did not include DRAs

Study	Date	Transect	Distance (m)
NE "all injury Data 4WAT"	*2017	Primary + Secondary	69
AR "all injury Data 4WAT"	*2017	Primary + Secondary	52
MO "all injury Data 4WAT"	*2017	Primary + Secondary	41.20
IN "all injury Data 4WAT"	*2017	Primary + Secondary	1

Table F.6. XtendiMax product OFM studies that included DRAs

Study	Date	Transect	Distance (m)
Norsworthy	7/16/2018	B&L P+S East Downwind	136
Norsworthy	7/16/2018	Nors P+S East-Downwind	113
MRID 51017501	2019-MO	DWA - P + S	109.04
MRID 51017501	2019-MO	DWB - P + S	91.82
MRID 51017501	2019-MO	DWC - P + S	> 90
MRID 51017501	2019-MO	LWB - P + S	50.42
VGX - MRID 51111901	2019-IL	RWA	> 50
MRID 51017501	2019-MO	LWA - P + S	48.71
MRID 51017501	2019-MO	NE - P + S	44.01
VGX - MRID 51111901	2019-IL	NE	< 40
MRID 50958201	2019-NE MO	DWC Drift	39.30
Norsworthy	7/16/2018	Nors P+S West-Upwind	34
MRID 50958201	2019-NE MO	SE Drift	31.51
MRID 50958201	2019-NE MO	DWB Drift	29.6
50642801	5/8/2018	Drift 3	27.46
Sprague	6/12/2018	A	25
VGX - MRID 51111901	2019-IL	NW	24.67
VGX - Academic (MRID 51134102)	2019-WI	N-P+S	23.5
Sprague	6/12/2018	C	22
Young	8/9/2018	Middle Transect	19.63
50642801	5/8/2018	Drift 2	19.32
TN "all injury Data 4WAT"	*2017	Primary + Secondary	18.64
MRID 50958201	2019-NE MO	DWA Drift	18.0
Young	8/9/2018	North Transect	16.73
MRID 50958201	2019-NE MO	RWB Drift	16.69
Werle	7/11/2018	N-1 (untarped)	16.62
MRID 50958201	2019-NE MO	RWA Drift	15.45
Werle	7/11/2018	N-2 (untarped)	15.22
VGX - MRID 51111901	2019-IL	LWA	13.44
Werle	7/11/2018	N-3 (untarped)	11.93
VGX - MRID 51111901	2019-IL	LWB	11.14
VGX - MRID 51111901	2019-IL	DWB	< 10.0
VGX - MRID 51111901	2019-IL	DWC	8.4
VGX - Academic (MRID 51134102)	2019-WI	W-P+S	8.3
VGX - Academic (MRID 51134102)	2019-NE	S-S	< 6
VGX - Academic (MRID 51134102)	2019-NE	W-S	< 6
Young	8/9/2018	South Transect	5.72

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Study	Date	Transect	Distance (m)
VGX - MRID 51111901	2019-IL	DWA	< 5.0
MRID 50958201	2019-NE MO	LWB Drift	< 5
50642801	5/8/2018	Drift 1	3.57
MRID 50958201	2019-NE MO	NW Drift	3
MRID 50958201	2019-NE MO	SW Drift	3
MRID 50958201	2019-NE MO	UWA Drift	3
MRID 50958201	2019-NE MO	UWB Drift	3
MRID 51017501	2019-MO	SW - P + S	< 3
MRID 51017501	2019-MO	UWA - P + S	< 3
MRID 51017501	2019-MO	RWA - P + S	< 3
MRID 51017501	2019-MO	SE - P + S	< 3
MRID 50958201	2019-NE MO	LWA Drift	< 3
MRID 50958201	2019-NE MO	NE Drift	< 3
VGX - MRID 51111901	2019-IL	RWB	< 3
VGX - MRID 51111901	2019-IL	SE	< 3
VGX - MRID 51111901	2019-IL	SW	< 3
VGX - MRID 51111901	2019-IL	UWA	< 3
VGX - MRID 51111901	2019-IL	UWB	< 3
VGX - Academic (MRID 51134102)	2019-WI	E-P+S	2.6
Sprague	6/12/2018	B	2
VGX - Academic (MRID 51134102)	2019-NE	N-S	< 2
VGX - Academic (MRID 51134102)	2019-NE	E-S	< 2
VGX - Academic (MRID 51134102)	2019-WI	S-P+S	< 1.5
MRID 51017501	2019-MO	RWB - P + S	0.13
Werle	7/11/2018	S (untarped)	0

3. Evaluation of the Distance Estimates from Studies that Included Volatility Reducing Agents (VRAs)

In evaluating the impacts of volatility to nontarget plants, EPA estimated the distance to 10% VSI (see discussion in **Appendix D**), using the available Off-Field Movement (OFM) studies submitted by the registrants and academia (**Appendix E**). When determining the off-field distance to effect (**Section F.1**) EPA did not separate out the data based on whether or not a volatility reducing agent (VRA), as the number of studies with VRAs was limited.

Taking into account the total number of volatile exposure transects for the available field studies using a VRA (**Table F.7**), the probability that the in-field 57 ft omnidirectional volatility setback would prevent dicamba air concentrations associated with observations of 10% VSI was calculated. Out of a total of 45 distance estimates, 5 (or 11%) distance estimates exceeded 57 ft. Therefore, the probability of success for the volatility setback of 57ft is 89%. This was used in the cumulative probability analyses discussed in **Appendix J.**

Table F.7. 10%VSI Distance estimates for studies that included a VRA.

Study	Date	Transect	Distance (ft)
BAPMA MRID 51049003	2019-MS	DWA - S	47
BAPMA MRID 51049003	2019-MS	DWB - S	41
BAPMA MRID 51049003	2019-MS	DWC - S	11
BAPMA MRID 51049003	2019-MS	LWA - S	110
BAPMA MRID 51049003	2019-MS	LWB - S	99
BAPMA MRID 51049003	2019-MS	UWA - S	31
BAPMA MRID 51049003	2019-MS	UWB - S	10
BAPMA MRID 51049003	2019-MS	RWA - S	66
BAPMA MRID 51049003	2019-MS	RWB - S	66
BAPMA MRID 51049004	2019-IL	DWA - S	10
BAPMA MRID 51049004	2019-IL	DWB - S	10
BAPMA MRID 51049004	2019-IL	DWC - S	10
BAPMA MRID 51049004	2019-IL	LWA - S	10
BAPMA MRID 51049004	2019-IL	LWB - S	10
BAPMA MRID 51049004	2019-IL	UWA - S	10
BAPMA MRID 51049004	2019-IL	UWB - S	10
BAPMA MRID 51049004	2019-IL	RWA - S	10
BAPMA MRID 51049004	2019-IL	RWB - S	16
DGA-VGX MRID 51111901	2019-IL	DWA	10
DGA-VGX MRID 51111901	2019-IL	DWB	10
DGA-VGX MRID 51111901	2019-IL	DWC	10
DGA-VGX MRID 51111901	2019-IL	LWA	10
DGA-VGX MRID 51111901	2019-IL	LWB	10
DGA-VGX MRID 51111901	2019-IL	UWA	10
DGA-VGX MRID 51111901	2019-IL	UWB	10
VGX - Academic (MRID 51134102)	2019-WI	N-S	78

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Study	Date	Transect	Distance (ft)
VGX - Academic (MRID 51134102)	2019-WI	E-S	3
VGX - Academic (MRID 51134102)	2019-WI	S-S	9
VGX - Academic (MRID 51134102)	2019-WI	W-S	5
VGX - Academic (MRID 51134102)	2019-NE	N-S	3
VGX - Academic (MRID 51134102)	2019-NE	E-S	3
VGX - Academic (MRID 51134102)	2019-NE	S-S	3
VGX - Academic (MRID 51134102)	2019-NE	W-S	3
VGX - Academic (MRID 51134102)	2019-GA[1]	E	<25
VGX - Academic (MRID 51134102)	2019-GA[1]	N	<25
VGX - Academic (MRID 51134102)	2019-GA[1]	NE	<25
VGX - Academic (MRID 51134102)	2019-GA[1]	NW	<25
VGX - Academic (MRID 51134102)	2019-GA[1]	S	<25
VGX - Academic (MRID 51134102)	2019-GA[1]	SE	<25
VGX - Academic (MRID 51134102)	2019-GA[1]	SW	50
VGX - Academic (MRID 51134102)	2019-GA[1]	W	<25
VGX - Academic (MRID 51134102)	2019-AL[1]	N	<50
VGX - Academic (MRID 51134102)	2019-AL[1]	W	<50
VGX - Academic (MRID 51134102)	2019-AL[1]	E	<50
VGX - Academic (MRID 51134102)	2019-AL[1]	S	<50

[1] These data were not used in the analyses presented in Section F.1 because of limitations in their designs or reporting (see **Appendix E** for details).

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4. Crystal Ball Input and Output Tables.

Table F.8. Crystal Ball Input Data for 5% height distances along Spray drift + volatility (uncovered) transects.

Study	Date	Transect	Distance (m)
Norsworthy	7/20/2017	transect 1	6
Norsworthy	7/20/2017	transect 2	32
Norsworthy	7/20/2017	transect 3	55
Norsworthy	7/20/2017	transect 4	1
MRID 51049003	2019-MS	DWA	63.7
MRID 51049003	2019-MS	DWB	42.5
MRID 51049003	2019-MS	DWC	24.4
MRID 51049003	2019-MS	LWA	243.4
MRID 51049003	2019-MS	LWB	21.3
MRID 51049003	2019-MS	UWA	60
MRID 51049003	2019-MS	UWB	40
MRID 51049003	2019-MS	RWA	5
MRID 51049003	2019-MS	RWB	60
MRID 51049003	2019-MS	NE	25.7
MRID 51049003	2019-MS	NW	10
MRID 51049003	2019-MS	SE	60
MRID 51049003	2019-MS	SW	40
MRID 51049004	2019-IL	DWA	5
MRID 51049004	2019-IL	DWB	32
MRID 51049004	2019-IL	DWC	36
MRID 51049004	2019-IL	LWA	3
MRID 51049004	2019-IL	LWB	50
MRID 51049004	2019-IL	UWA	20
MRID 51049004	2019-IL	UWB	3
MRID 51049004	2019-IL	RWA	60
MRID 51049004	2019-IL	RWB	3
MRID 51049004	2019-IL	N	125
MRID 51049004	2019-IL	S	3
MRID 51049004	2019-IL	E	20
MRID 51049004	2019-IL	W	3
Norsworthy	7/20/2017		3
Werle	7/11/2018	N-1 (untarped)	0
Werle	7/11/2018	N-2 (untarped)	0
Werle	7/11/2018	N-3 (untarped)	0
Werle	7/11/2018	S (untarped)	9
Sprague	6/12/2018	A	10
Sprague	6/12/2018	B	0

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Study	Date	Transect	Distance (m)
Sprague	6/12/2018	C	0
Kruger	7/10/2018	Uncovered transect 1	12
Kruger	7/10/2018	Uncovered transect 2	9
Kruger	7/10/2018	Uncovered transect 3	9
MRID 51017501	2019-MO	DWA - P + S	56
MRID 51017501	2019-MO	DWB - P + S	59
MRID 51017501	2019-MO	DWC - P + S	67
MRID 51017501	2019-MO	LWA - P + S	16
MRID 51017501	2019-MO	LWB - P + S	11
MRID 51017501	2019-MO	NE - P + S	22
MRID 51017501	2019-MO	RWA - P + S	10
MRID 51017501	2019-MO	RWB - P + S	10
MRID 51017501	2019-MO	SE - P + S	10
MRID 51017501	2019-MO	SW - P + S	60
MRID 51017501	2019-MO	UWA - P + S	10
VGX - Academic (MRID 51134102)	2019-WI	N-P+S	5
VGX - Academic (MRID 51134102)	2019-WI	E-P+S	1
VGX - Academic (MRID 51134102)	2019-WI	S-P+S	2
VGX - Academic (MRID 51134102)	2019-WI	W-P+S	1
VGX - MRID 51111901	2019-IL	DWA	36.6
VGX - MRID 51111901	2019-IL	DWB	76.1
VGX - MRID 51111901	2019-IL	DWC	37.3
VGX - MRID 51111901	2019-IL	LWA	60
VGX - MRID 51111901	2019-IL	LWB	59.2
VGX - MRID 51111901	2019-IL	NE	40
VGX - MRID 51111901	2019-IL	NW	35.9
VGX - MRID 51111901	2019-IL	RWA	60
VGX - MRID 51111901	2019-IL	RWB	3
VGX - MRID 51111901	2019-IL	SE	60
VGX - MRID 51111901	2019-IL	SW	60
VGX - MRID 51111901	2019-IL	UWA	5
VGX - MRID 51111901	2019-IL	UWB	60
VGX - Academic (MRID 51134102)	2019-NE	N-S	1
VGX - Academic (MRID 51134102)	2019-NE	E-S	10
VGX - Academic (MRID 51134102)	2019-NE	S-S	1
VGX - Academic (MRID 51134102)	2019-NE	W-S	10

Table F.9. Crystal Ball Input Data for 5% height distances along volatility (covered) transects.

Study	Date	Transect	Distance (m)
MRID 51049003	2019-MS	DWA - S	3
MRID 51049003	2019-MS	DWB - S	3
MRID 51049003	2019-MS	DWC - S	20
MRID 51049003	2019-MS	LWA - S	3
MRID 51049003	2019-MS	LWB - S	3
MRID 51049003	2019-MS	UWA - S	20
MRID 51049003	2019-MS	UWB - S	20
MRID 51049003	2019-MS	RWA - S	3
MRID 51049003	2019-MS	RWB - S	20
MRID 51049004	2019-IL	DWA - S	3
MRID 51049004	2019-IL	DWB - S	3
MRID 51049004	2019-IL	DWC - S	3
MRID 51049004	2019-IL	LWA - S	10
MRID 51049004	2019-IL	LWB - S	20
MRID 51049004	2019-IL	UWA - S	3
MRID 51049004	2019-IL	UWB - S	3
MRID 51049004	2019-IL	RWA - S	3
MRID 51049004	2019-IL	RWB - S	3
MRID 51017501	2019-MO	DWA - S	14
MRID 51017501	2019-MO	DWB - S	16
MRID 51017501	2019-MO	LWA - S	5
MRID 51017501	2019-MO	LWB - S	5
MRID 51017501	2019-MO	RWA - S	3
MRID 51017501	2019-MO	RWB - S	8
MRID 51017501	2019-MO	UWA - S	5
MRID 51017501	2019-MO	UWB - S	12
VGX - MRID 51111901	2019-IL	DWA	16.9
VGX - MRID 51111901	2019-IL	DWB	20
VGX - MRID 51111901	2019-IL	DWC	20
VGX - MRID 51111901	2019-IL	LWA	10
VGX - MRID 51111901	2019-IL	LWB	20
VGX - MRID 51111901	2019-IL	UWA	20
VGX - MRID 51111901	2019-IL	UWB	3
VGX - Academic (MRID 51134102)	2019-WI	N-S	1
VGX - Academic (MRID 51134102)	2019-WI	E-S	1
VGX - Academic (MRID 51134102)	2019-WI	S-S	1
VGX - Academic (MRID 51134102)	2019-WI	W-S	1
VGX - Academic (MRID 51134102)	2019-NE	N-S	1
VGX - Academic (MRID 51134102)	2019-NE	E-S	1
VGX - Academic (MRID 51134102)	2019-NE	S-S	1
VGX - Academic (MRID 51134102)	2019-NE	W-S	15

Table F.10. Crystal Ball Input Data for 5% height distances along Spray drift + volatility (uncovered) transects.

Study	Date	Transect	Distance (m)
Jones	42557	N	59.37567
Jones	42557	NE	56.80685
Jones	42557	E	37.29032
Jones	42557	SE	20.97126
Jones	42557	S	8.559908
Jones	42557	SW	0.001806
Jones	42557	W	5.694231
Jones	42557	NW	11.08857
MO "all injury Data 4WAT"	*2017	Primary + Secondary	27.59944
TN "all injury Data 4WAT"	*2017	Primary + Secondary	27.46434
NE "all injury Data 4WAT"	*2017	Primary + Secondary	61.95233
IN "all injury Data 4WAT"	*2017	Primary + Secondary	8.633498
AR "all injury Data 4WAT"	*2017	Primary + Secondary	39.73688
MRID 51049003	2019-MS	DWA	90.99886
MRID 51049003	2019-MS	DWB	103.0386
MRID 51049003	2019-MS	DWC	60.54417
MRID 51049003	2019-MS	LWA	87.33537
MRID 51049003	2019-MS	LWB	111.6115
MRID 51049003	2019-MS	UWA	60
MRID 51049003	2019-MS	UWB	60
MRID 51049003	2019-MS	RWA	13.76958
MRID 51049003	2019-MS	RWB	2.192948
MRID 51049003	2019-MS	NE	60.63964
MRID 51049003	2019-MS	NW	3
MRID 51049003	2019-MS	SE	60
MRID 51049003	2019-MS	SW	60
MRID 51049004	2019-IL	DWA	34.20844
MRID 51049004	2019-IL	DWB	51.87645
MRID 51049004	2019-IL	DWC	49.92192
MRID 51049004	2019-IL	LWA	0.4883
MRID 51049004	2019-IL	LWB	0.607073
MRID 51049004	2019-IL	UWA	28.62279
MRID 51049004	2019-IL	UWB	3
MRID 51049004	2019-IL	RWA	3
MRID 51049004	2019-IL	RWB	3
MRID 51049004	2019-IL	N	3
MRID 51049004	2019-IL	S	3
MRID 51049004	2019-IL	E	3
MRID 51049004	2019-IL	W	3
MRID 50642801	5/8/2018	Drift 1	3.571429

Study	Date	Transect	Distance (m)
MRID 50642801	5/8/2018	Drift 2	19.32203
MRID 50642801	5/8/2018	Drift 3	27.46369
Norsworthy	7/16/2018	B&L P+S East Downwind	136
Norsworthy	7/16/2018	Nors P+S East-Downwind	113
Norsworthy	7/16/2018	Nors P+S West-Upwind	34
Werle	7/11/2018	N-1 (untarped)	16.62157
Werle	7/11/2018	N-2 (untarped)	15.21597
Werle	7/11/2018	N-3 (untarped)	11.92508
Werle	7/11/2018	S (untarped)	0
Young	8/9/2018	North Transect	16.72539
Young	8/9/2018	South Transect	5.719129
Young	8/9/2018	Middle Transect	19.63074
Sprague	6/12/2018	A	25
Sprague	6/12/2018	B	2
Sprague	6/12/2018	C	22
MO "all injury Data 4WAT"	*2017	Primary + Secondary	41.19599
TN "all injury Data 4WAT"	*2017	Primary + Secondary	18.63564
NE "all injury Data 4WAT"	*2017	Primary + Secondary	69
IN "all injury Data 4WAT"	*2017	Primary + Secondary	1
AR "all injury Data 4WAT"	*2017	Primary + Secondary	52
MRID 51017501	2019-MO	DWA - P + S	109.0433
MRID 51017501	2019-MO	DWB - P + S	91.81953
MRID 51017501	2019-MO	DWC - P + S	90
MRID 51017501	2019-MO	LWA - P + S	48.70592
MRID 51017501	2019-MO	LWB - P + S	50.42229
MRID 51017501	2019-MO	NE - P + S	44.00547
MRID 51017501	2019-MO	RWA - P + S	3
MRID 51017501	2019-MO	RWB - P + S	0.127999
MRID 51017501	2019-MO	SE - P + S	3
MRID 51017501	2019-MO	SW - P + S	3
MRID 51017501	2019-MO	UWA - P + S	3
MRID 50958201	2019-NE MO	DWA Drift	18.0
MRID 50958201	2019-NE MO	DWB Drift	29.6
MRID 50958201	2019-NE MO	DWC Drift	39.29614
MRID 50958201	2019-NE MO	LWA Drift	3
MRID 50958201	2019-NE MO	LWB Drift	5
MRID 50958201	2019-NE MO	NE Drift	3
MRID 50958201	2019-NE MO	NW Drift	3
MRID 50958201	2019-NE MO	RWA Drift	15.45254
MRID 50958201	2019-NE MO	RWB Drift	16.6851
MRID 50958201	2019-NE MO	SE Drift	31.51058
MRID 50958201	2019-NE MO	SW Drift	3

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Study	Date	Transect	Distance (m)
MRID 50958201	2019-NE MO	UWA Drift	3
MRID 50958201	2019-NE MO	UWB Drift	3
VGX - MRID 51111901	2019-IL	DWA	5.0
VGX - MRID 51111901	2019-IL	DWB	10.0
VGX - MRID 51111901	2019-IL	DWC	8.4
VGX - MRID 51111901	2019-IL	LWA	13.4397
VGX - MRID 51111901	2019-IL	LWB	11.14254
VGX - MRID 51111901	2019-IL	NE	40
VGX - MRID 51111901	2019-IL	NW	24.67026
VGX - MRID 51111901	2019-IL	RWA	50
VGX - MRID 51111901	2019-IL	RWB	3
VGX - MRID 51111901	2019-IL	SE	3
VGX - MRID 51111901	2019-IL	SW	3
VGX - MRID 51111901	2019-IL	UWA	3
VGX - MRID 51111901	2019-IL	UWB	3
VGX - Academic (MRID 51134102)	2019-WI	N-P+S	23.5
VGX - Academic (MRID 51134102)	2019-WI	E-P+S	2.6
VGX - Academic (MRID 51134102)	2019-WI	S-P+S	1.5
VGX - Academic (MRID 51134102)	2019-WI	W-P+S	8.3
VGX - Academic (MRID 51134102)	2019-NE	N-S	2
VGX - Academic (MRID 51134102)	2019-NE	E-S	2
VGX - Academic (MRID 51134102)	2019-NE	S-S	6
VGX - Academic (MRID 51134102)	2019-NE	W-S	6

Table F.11. Crystal Ball Input Data for 10% VSI distances along volatility (covered) transects.

Study	Date	Transect	Distance (m)
MO "all injury Data 4WAT"	*2017	Secondary	9.62422622
TN "all injury Data 4WAT"	*2017	Secondary	9.749364199
NE "all injury Data 4WAT"	*2017	Secondary	67
IN "all injury Data 4WAT"	*2017	Secondary	3
AR "all injury Data 4WAT"	*2017	Secondary	26
Norsworthy 8-14 Volatility North	*2017	Transect 1	32.9428104
Norsworthy 8-14 Volatility North	*2017	Transect 2	40.35123005
Norsworthy 8-14 Volatility North	*2017	Transect 3	36.62444156
Norsworthy 8-14 Volatility North	*2017	Transect 4	37.51753799
MRID 51049003	2019-MS	DWA - S	14.21867136
MRID 51049003	2019-MS	DWB - S	12.59021256
MRID 51049003	2019-MS	DWC - S	3.356646605
MRID 51049003	2019-MS	LWA - S	33.4246172
MRID 51049003	2019-MS	LWB - S	30.09721536
MRID 51049003	2019-MS	UWA - S	9.501323021
MRID 51049003	2019-MS	UWB - S	3
MRID 51049003	2019-MS	RWA - S	20
MRID 51049003	2019-MS	RWB - S	20
MRID 51049004	2019-IL	DWA - S	3
MRID 51049004	2019-IL	DWB - S	3
MRID 51049004	2019-IL	DWC - S	3
MRID 51049004	2019-IL	LWA - S	3
MRID 51049004	2019-IL	LWB - S	3
MRID 51049004	2019-IL	UWA - S	3
MRID 51049004	2019-IL	UWB - S	3
MRID 51049004	2019-IL	RWA - S	3
MRID 51049004	2019-IL	RWB - S	5
MRID 50642801	5/8/2018	Volatility 1	0
MRID 50642801	5/8/2018	Volatility 2	0
MRID 50642801	5/8/2018	Volatility 3	0
Norsworthy	7/16/2018	Nors S East-Downwind	109.6342795
Werle	7/11/2018	N-1 (tarped)	12.43378287
Werle	7/11/2018	N-2 (tarped)	8.500625167
Werle	7/11/2018	N-3 (tarped)	7.507979487
Werle	7/11/2018	S (tarped)	0
MO "all injury Data 4WAT"	*2017	Secondary	14.2836182
TN "all injury Data 4WAT"	*2017	Secondary	1.017117988
NE "all injury Data 4WAT"	*2017	Secondary	60.30954424
IN "all injury Data 4WAT"	*2017	Secondary	0
AR "all injury Data 4WAT"	*2017	Secondary	40.71651999
Norsworthy 8-14 Volatility North	*2017	Transect 1	27.65141235

Study	Date	Transect	Distance (m)
Norsworthy 8-14 Volatility North	*2017	Transect 2	40.66218602
Norsworthy 8-14 Volatility North	*2017	Transect 3	31.34462293
Norsworthy 8-14 Volatility North	*2017	Transect 4	23.02561892
MRID 51017501	2019-MO	DWA - S	20
MRID 51017501	2019-MO	DWB - S	20
MRID 51017501	2019-MO	LWA - S	3
MRID 51017501	2019-MO	LWB - S	3
MRID 51017501	2019-MO	RWA - S	3
MRID 51017501	2019-MO	RWB - S	3
MRID 51017501	2019-MO	UWA - S	3
MRID 51017501	2019-MO	UWB - S	20
MRID 50958201	2019-NE MO	DWA- S	3
MRID 50958201	2019-NE MO	DWB- S	3
MRID 50958201	2019-NE MO	DWC- S	3
MRID 50958201	2019-NE MO	LWA- S	3
MRID 50958201	2019-NE MO	LWB- S	3
MRID 50958201	2019-NE MO	UWA- S	3
MRID 50958201	2019-NE MO	UWB- S	3
MRID 50958201	2019-NE MO	RWA- S	3
MRID 50958201	2019-NE MO	RWB- S	3
VGX - MRID 51111901	2019-IL	DWA	3
VGX - MRID 51111901	2019-IL	DWB	3
VGX - MRID 51111901	2019-IL	DWC	3
VGX - MRID 51111901	2019-IL	LWA	3
VGX - MRID 51111901	2019-IL	LWB	3
VGX - MRID 51111901	2019-IL	UWA	3
VGX - MRID 51111901	2019-IL	UWB	3
VGX - Academic (MRID 51134102)	2019-WI	N-S	23.88491369
VGX - Academic (MRID 51134102)	2019-WI	E-S	1
VGX - Academic (MRID 51134102)	2019-WI	S-S	2.6
VGX - Academic (MRID 51134102)	2019-WI	W-S	1.5
VGX - Academic (MRID 51134102)	2019-NE	N-S	1
VGX - Academic (MRID 51134102)	2019-NE	E-S	1
VGX - Academic (MRID 51134102)	2019-NE	S-S	1
VGX - Academic (MRID 51134102)	2019-NE	W-S	1

Table F.12. Crystal Ball Output Data for 5% height distances along Spray drift + volatility (uncovered) transects.

Forecast: P 5% Height Combined

Summary:
Entire range is from 0.00 to
422.99
Base case is 1.00
After 10,000 trials, the std. error of the mean is 0.37

Statistics:	Forecast values
Trials	10,000
Base Case	1.00
Mean	30.38
Median	17.80
Mode	---
Standard Deviation	36.75
Variance	1,350.83
Skewness	2.58
Kurtosis	13.43
Coeff. of Variation	1.21
Minimum	0.00
Maximum	422.99
Range Width	422.99
Mean Std. Error	0.37

Forecast: P 5% Height Combined
(cont'd)

Percentiles:	Forecast values
0%	0.00
1%	0.10
2%	0.22

279

3%	0.36
4%	0.55
5%	0.72
10%	1.79
25%	6.01
50%	17.80
90%	75.76
95%	104.62
100%	422.99

Assumptions

Weibull distribution with parameters:

Location	0.00
Scale	26.80
Shape	0.822276756
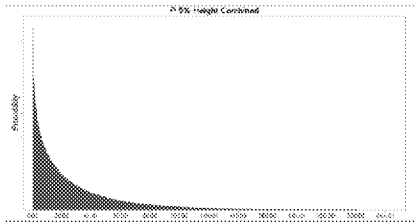
Statistics:	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	30.38	29.79
Median	17.80	17.16
Mode	---	---
Standard Deviation	36.75	36.45
Variance	1,350.83	1,328.94
Skewness	2.58	2.70
Kurtosis	13.43	14.59
Coeff. of Variation	1.21	1.22
Minimum	0.00	0.00
Maximum	422.99	∞
Range Width	422.99	---
Mean Std. Error	0.37	---

Percentiles:	Assumption values	Distribution
0%	0.00	0.00
5%	0.72	0.72
10%	1.79	1.74
15%	2.93	2.94
20%	4.48	4.32
25%	6.01	5.89
30%	7.83	7.65

35%	9.76	9.62
40%	12.09	11.84
45%	14.84	14.33
50%	17.80	17.16
55%	21.08	20.38
60%	24.67	24.09
65%	28.79	28.43
70%	34.33	33.58
75%	40.82	39.86
80%	48.89	47.80
85%	59.62	58.38
90%	75.76	73.89
95%	104.62	101.76
100%	422.99	∞

Table F.13. Crystal Ball Output for 5% height distances along volatility (covered) transects.
Forecast: S 5% Ht Combined

Summary:
Entire range is from 0.00 to
103.36
Base case is 1.00
After 10,000 trials, the std. error of the mean is
0.07
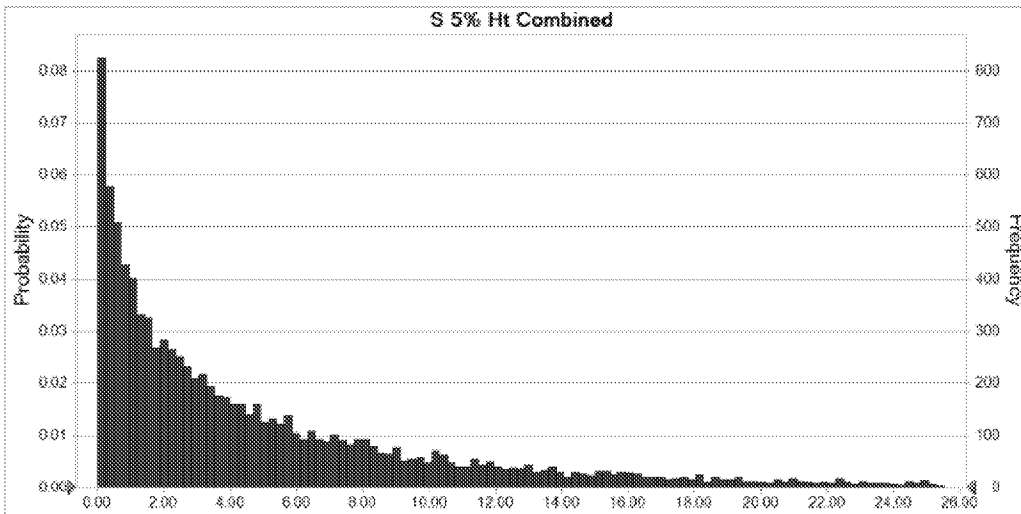
Statistics:	Forecast values
Trials	10,000
Base Case	1.00
Mean	5.63
Median	3.13
Mode	---
Standard Deviation	7.11
Variance	50.53
Skewness	2.93
Kurtosis	17.64
Coeff. of Variation	1.26
Minimum	0.00
Maximum	103.36
Range Width	103.36
Mean Std. Error	0.07

Forecast: S 5% Ht Combined (cont'd)

Percentiles:	Forecast values
0%	0.00
1%	0.02
2%	0.04
3%	0.07

282

4%	0.09
5%	0.12
10%	0.30
25%	1.02
50%	3.12
90%	14.16
95%	19.46
100%	103.36

Assumptions

Weibull distribution with parameters:

Location	0.00
Scale	4.89
Shape	0.805433619
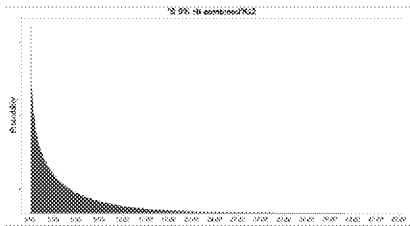
Statistics:	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	5.63	5.52
Median	3.13	3.10
Mode	---	---
Standard Deviation	7.11	6.90
Variance	50.53	47.64
Skewness	2.93	2.78
Kurtosis	17.64	15.45
Coeff. of Variation	1.26	1.25
Minimum	0.00	0.00
Maximum	103.36	∞
Range Width	103.36	---
Mean Std. Error	0.07	---

Percentiles:	Assumption values	Distribution
0%	0.00	0.00
5%	0.12	0.12
10%	0.30	0.30
15%	0.51	0.51
20%	0.76	0.76
25%	1.02	1.04

30%	1.34	1.36
35%	1.71	1.72
40%	2.14	2.12
45%	2.60	2.58
50%	3.12	3.10
55%	3.74	3.70
60%	4.46	4.39
65%	5.31	5.20
70%	6.30	6.16
75%	7.51	7.34
80%	8.98	8.83
85%	11.10	10.83
90%	14.16	13.78
95%	19.46	19.10
100%	103.36	∞

Table F.14. Crystal Ball Output for 5% height distances along Spray drift + volatility (uncovered) transects.

Entire range is from 0.00 to
151.11
Base case is
1.00
After 10,000 trials, the std. error of the mean is 0.31
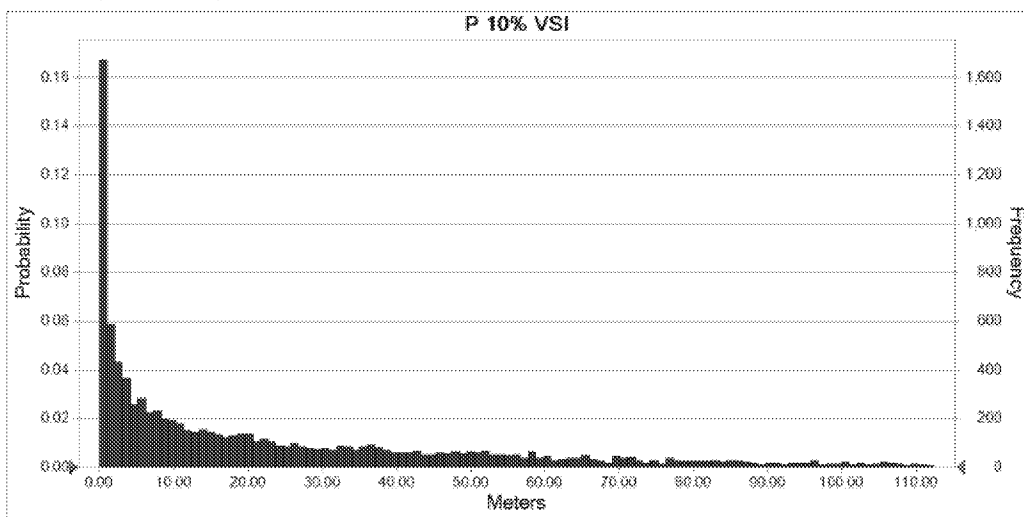
	Forecast values
Trials	10,000
Base Case	1.00
Mean	26.29
Median	14.02
Mode	---
Standard Deviation	30.73
Variance	944.10
Skewness	1.47
Kurtosis	4.60
Coeff. of Variation	1.17
Minimum	0.00
Maximum	151.11
Range Width	151.11
Mean Std. Error	0.31

	Forecast values
0%	0.00
1%	0.00
2%	0.01
3%	0.02
4%	0.05

5%	0.08
6%	0.10
7%	0.14
8%	0.20
9%	0.26
10%	0.32
11%	0.41
12%	0.49
13%	0.57
14%	0.68
15%	0.80
16%	0.92
17%	1.07
18%	1.20
19%	1.36
20%	1.52
21%	1.75
22%	1.93
23%	2.17
24%	2.38
25%	2.60
26%	2.86
27%	3.11
28%	3.40
29%	3.68
30%	3.95
31%	4.29
32%	4.74
33%	5.09
34%	5.52
35%	5.90
36%	6.20
37%	6.65
38%	7.13
39%	7.62
40%	8.00
41%	8.51
42%	9.05
43%	9.56
44%	10.08
45%	10.72
46%	11.24
47%	11.87
48%	12.58
49%	13.35
50%	14.02
51%	14.63
52%	15.30

53%	16.15
54%	16.95
55%	17.72
56%	18.52
57%	19.27
58%	19.97
59%	20.80
60%	21.81
61%	22.70
62%	23.70
63%	24.83
64%	25.94
65%	27.06
66%	28.33
67%	29.54
68%	30.97
69%	32.40
70%	33.44
71%	34.78
72%	36.12
73%	37.22
74%	38.56
75%	40.11
76%	41.84
77%	43.45
78%	45.41
79%	47.07
80%	48.83
81%	50.68
82%	52.12
83%	54.08
84%	56.23
85%	58.21
86%	60.52
87%	63.51
88%	66.12
89%	69.64
90%	72.16
91%	76.50
92%	79.87
93%	84.13
94%	88.37
95%	94.59
96%	100.15
97%	106.42
98%	114.34
99%	124.76
100%	151.11

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Assumption: P 10% VSI

Beta distribution with parameters:
Minimum   0.00
Maximum   155.84
Alpha   0.446705953
Beta   2.173406503
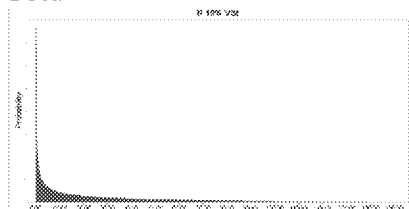
Statistics:	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	26.29	26.57
Median	14.02	14.17
Mode	---	0.00
Standard Deviation	30.73	30.80
Variance	944.10	948.81
Skewness	1.47	1.44
Kurtosis	4.60	4.50
Coeff. of Variation	1.17	1.16
Minimum	0.00	0.00
Maximum	151.11	155.84
Range Width	151.11	155.84
Mean Std. Error	0.31	---

Assumption: P 10% VSI (cont'd)

Percentiles:	Assumption values	Distribution
0%	0.00	0.00
1%	0.00	0.00
2%	0.01	0.01
3%	0.02	0.02
4%	0.05	0.05
5%	0.08	0.08
6%	0.10	0.11
7%	0.14	0.16
8%	0.20	0.22
9%	0.26	0.28
10%	0.32	0.36
11%	0.41	0.44
12%	0.49	0.54

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13%	0.57	0.65
14%	0.68	0.76
15%	0.80	0.89
16%	0.92	1.03
17%	1.07	1.18
18%	1.20	1.34
19%	1.36	1.52
20%	1.52	1.71
21%	1.75	1.90
22%	1.93	2.12
23%	2.17	2.34
24%	2.38	2.58
25%	2.60	2.83
26%	2.86	3.09
27%	3.11	3.37
28%	3.40	3.66
29%	3.68	3.97
30%	3.95	4.29
31%	4.29	4.62
32%	4.74	4.97
33%	5.09	5.33
34%	5.52	5.71
35%	5.90	6.11
36%	6.20	6.52
37%	6.65	6.95
38%	7.13	7.39
39%	7.62	7.86
40%	8.00	8.34
41%	8.51	8.83
42%	9.05	9.35
43%	9.56	9.88
44%	10.08	10.43
45%	10.72	11.00
46%	11.24	11.60
47%	11.87	12.21
48%	12.58	12.84
49%	13.35	13.49
50%	14.02	14.17
51%	14.63	14.87
52%	15.30	15.59
53%	16.15	16.33
54%	16.95	17.10
55%	17.72	17.89
56%	18.52	18.71
57%	19.27	19.55
58%	19.97	20.43
59%	20.80	21.33
60%	21.81	22.25

61%	22.70	23.21
62%	23.70	24.20
63%	24.83	25.23
64%	25.94	26.28
65%	27.06	27.37
66%	28.33	28.50
67%	29.54	29.66
68%	30.97	30.86
69%	32.40	32.11
70%	33.44	33.39
71%	34.78	34.73
72%	36.12	36.10
73%	37.22	37.53
74%	38.56	39.01
75%	40.11	40.55
76%	41.84	42.14
77%	43.45	43.79
78%	45.41	45.51
79%	47.07	47.31
80%	48.83	49.17
81%	50.68	51.12
82%	52.12	53.15
83%	54.08	55.28
84%	56.23	57.51
85%	58.21	59.86
86%	60.52	62.33
87%	63.51	64.94
88%	66.12	67.70
89%	69.64	70.63
90%	72.16	73.77
91%	76.50	77.13
92%	79.87	80.77
93%	84.13	84.73
94%	88.37	89.08
95%	94.59	93.95
96%	100.15	99.48
97%	106.42	105.97
98%	114.34	113.97
99%	124.76	124.94
100%	151.11	155.84

Table F.15. Crystal Ball Output for 10% VSI distances along volatility (covered) transects.
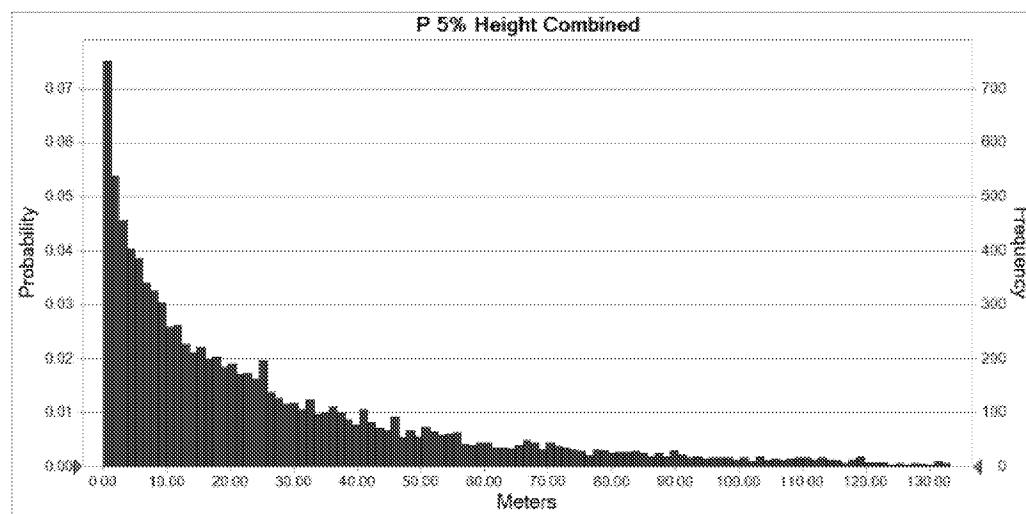
Forecast: S 10% VSI

Summary:
Entire range is from 0.00 to 190.51
Base case is 1.00
After 10,000 trials, the std. error of the mean is 0.18
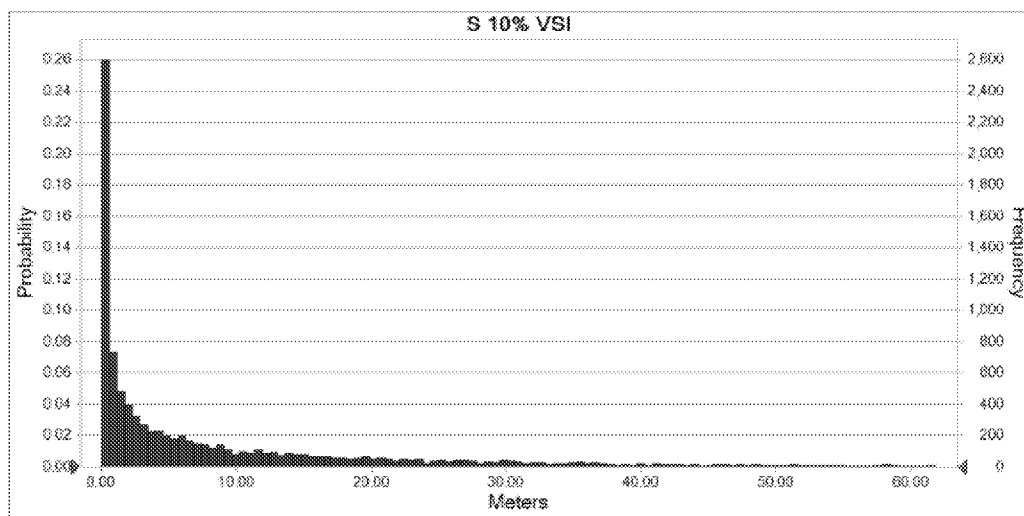
Statistics:	Forecast values
Trials	10,000
Base Case	1.00
Mean	11.52
Median	3.87
Mode	---
Standard Deviation	17.96
Variance	322.66
Skewness	2.74
Kurtosis	13.11
Coeff. of Variation	1.56
Minimum	0.00
Maximum	190.51
Range Width	190.51
Mean Std. Error	0.18

Forecast: S 10% VSI (cont'd)

Percentiles:	Forecast values
0%	0.00
1%	0.00
2%	0.00
3%	0.00

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4%	0.00
5%	0.01
6%	0.01
7%	0.02
8%	0.02
9%	0.03
10%	0.04
11%	0.05
12%	0.07
13%	0.08
14%	0.10
15%	0.12
16%	0.15
17%	0.18
18%	0.21
19%	0.24
20%	0.28
21%	0.31
22%	0.36
23%	0.41
24%	0.46
25%	0.51
26%	0.57
27%	0.63
28%	0.69
29%	0.75
30%	0.84
31%	0.91
32%	1.02
33%	1.11
34%	1.21
35%	1.33
36%	1.44
37%	1.57
38%	1.68
39%	1.81
40%	1.95
41%	2.11
42%	2.25
43%	2.43
44%	2.58
45%	2.77
46%	2.98
47%	3.18
48%	3.39
49%	3.65
50%	3.87
51%	4.13

52%	4.37
53%	4.64
54%	4.96
55%	5.22
56%	5.53
57%	5.83
58%	6.13
59%	6.43
60%	6.80
61%	7.17
62%	7.55
63%	7.96
64%	8.43
65%	8.85
66%	9.24
67%	9.91
68%	10.51
69%	11.14
70%	11.67
71%	12.26
72%	12.90
73%	13.61
74%	14.26
75%	15.03
76%	15.74
77%	16.55
78%	17.41
79%	18.41
80%	19.39
81%	20.28
82%	21.20
83%	22.33
84%	23.61
85%	25.17
86%	26.57
87%	27.91
88%	29.73
89%	31.15
90%	33.35
91%	35.57
92%	37.65
93%	41.35
94%	45.67
95%	49.37
96%	54.03
97%	61.09
98%	69.35
99%	82.88

100%   190.51

Assumption: S 10% VSI

Minimum	0.00	
Maximum	280.39	
Alpha	0.355133159	
Beta	8.055949042	
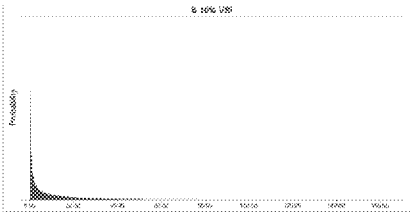
	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	11.52	11.84
Median	3.87	4.00
Mode	---	0.00
Standard Deviation	17.96	18.38
Variance	322.66	337.83
Skewness	2.74	2.68
Kurtosis	13.11	12.33
Coeff. of Variation	1.56	1.55
Minimum	0.00	0.00
Maximum	190.51	280.39
Range Width	190.51	280.39
Mean Std. Error	0.18	---

	Assumption values	Distribution
0%	0.00	0.00
1%	0.00	0.00
2%	0.00	0.00
3%	0.00	0.00
4%	0.00	0.00
5%	0.01	0.01
6%	0.01	0.01
7%	0.02	0.01
8%	0.02	0.02
9%	0.03	0.03
10%	0.04	0.04
11%	0.05	0.05
12%	0.07	0.07
13%	0.08	0.08
14%	0.10	0.10
15%	0.12	0.13

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16%	0.15	0.15
17%	0.18	0.18
18%	0.21	0.21
19%	0.24	0.24
20%	0.28	0.28
21%	0.31	0.32
22%	0.36	0.37
23%	0.41	0.42
24%	0.46	0.47
25%	0.51	0.53
26%	0.57	0.60
27%	0.63	0.66
28%	0.69	0.74
29%	0.75	0.81
30%	0.84	0.90
31%	0.91	0.98
32%	1.02	1.08
33%	1.11	1.18
34%	1.21	1.28
35%	1.33	1.40
36%	1.44	1.51
37%	1.57	1.64
38%	1.68	1.77
39%	1.81	1.91
40%	1.95	2.06
41%	2.11	2.21
42%	2.25	2.37
43%	2.43	2.55
44%	2.58	2.72
45%	2.77	2.91
46%	2.98	3.11
47%	3.18	3.32
48%	3.39	3.53
49%	3.65	3.76
50%	3.87	4.00
51%	4.13	4.24
52%	4.37	4.50
53%	4.64	4.78
54%	4.96	5.06
55%	5.22	5.36
56%	5.53	5.67
57%	5.83	5.99
58%	6.13	6.33
59%	6.43	6.69
60%	6.80	7.06
61%	7.17	7.44
62%	7.55	7.85
63%	7.96	8.27

64%	8.43	8.71
65%	8.85	9.18
66%	9.24	9.66
67%	9.91	10.17
68%	10.51	10.70
69%	11.14	11.26
70%	11.67	11.85
71%	12.26	12.46
72%	12.90	13.10
73%	13.61	13.78
74%	14.26	14.50
75%	15.03	15.25
76%	15.74	16.04
77%	16.55	16.88
78%	17.41	17.76
79%	18.41	18.70
80%	19.39	19.69
81%	20.28	20.75
82%	21.20	21.88
83%	22.33	23.08
84%	23.61	24.37
85%	25.17	25.76
86%	26.57	27.26
87%	27.91	28.88
88%	29.73	30.65
89%	31.15	32.58
90%	33.35	34.71
91%	35.57	37.09
92%	37.65	39.76
93%	41.35	42.79
94%	45.67	46.31
95%	49.37	50.47
96%	54.03	55.56
97%	61.09	62.07
98%	69.35	71.14
99%	82.88	86.17
100%	190.51	280.39

Appendix G. Additional Field Studies

1. Runoff Study (MRID 51017508)

Terms of the 2018 registrations for dicamba over-the-top applications required the registrants to conduct a study to evaluate the effects of dicamba-containing agricultural irrigation water on non-target plants. Runoff of dicamba diglycolamine salt (Clarity®) under U.S. field conditions was examined in cropped plots of dicamba tolerant soybeans on two plots near Fisk, Missouri. The nominal application rate for each treated plot was 0.5 lbs. a.e./A. Furrow irrigation was applied to the control and Plot 1 two days after the test substance application (September 5, 2019), while furrow irrigation was applied to Plot 2 seven days after the test substance application (September 10, 2019). Runoff samples were collected from Plot 1 over ten intervals through ca. 3 ½ hours and from Plot 2 over twelve intervals through ca. 5 ½ hours following the beginning of runoff. The treated plots were 4.6 m apart, and the control plot was ca. 32 m away from the nearest treated plot.

Under field conditions at Plot 1, 9,100 gallons (0.34 A-in) of water were applied to the plot, with 5,170 gallons (0.19 A-in) of runoff. Dicamba runoff concentrations ranged from 377 to 465 µg/L at the start of the runoff event to 21.2 to 39.2 µg/L at the end of the runoff event, with sample concentrations generally decreasing over time. At the end of the study, the total mass lost of dicamba was 0.25% of the target applied amount, with a flow-weighted average concentration of 39.7 µg/L for the 3.5 hours of runoff.

Under field conditions at Plot 2, 14,576 gallons (0.54 A-in) of water were applied to the plot, with 5,483 gallons (0.2 A-in) of runoff. Dicamba runoff concentrations ranging from 352 to 432 µg/L at the start of the runoff event to 5.73 to 13.8 µg/L at the end of the runoff event, with sample concentrations generally decreasing over time. At the end of the study, the total mass lost of dicamba was 0.12% of the target applied amount, with a time-weighted average concentration of 16.8 µg/L for the 6 hours of runoff.

Both plots had total areas of 1.38 A (5,578 m^2), with the amount of water applied equivalent to 0.25 and 0.39 in. of water over a 2.5 and 5-hour period. The total runoff was approximately 0.15 in. of water leaving each field (38-60% of water applied). If the runoff water were used as irrigation or were to leave the field, the effective concentrations in the water would be 1.33×10^{-3} and 5.62×10^{-4} lb dicamba/A, which exceed the vegetative vigor IC_{25} for soybeans (5.13×10^{-4} lb ae/A). An example calculation is provided below for Plot 1.

39.7 µg/L x 0.15 in x 1000 L/m^3 x 0.025 m/in = 148.88 µg/m^2

148.88 µg/m^2 x 1 kg/1x10^9 µg x 10,000 m^2/ha x 1 lb/A / 1.12 kg/ha = 1.33×10^{-3} lb/A

It should be noted that for Missouri, precipitation in June and July is comparable to the 0.25 and 0.39 in. runoff values. Historical averages for the last 100 years for the months of June and July are 4.62 and 3.71 in. of rain per month (https://www.ncdc.noaa.gov/cag/statewide/time-series), respectively, or 0.31 to 0.39 in. per day if rain occurred 12 days out of the month. If the flow-weighted average concentrations remained the same as those reported in the study, the effective concentrations would still be above the IC_{25} for soybeans.

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Based on the results of the study, runoff would be expected to occur such that concentrations leaving the field would exceed the soybean IC_{25} even 7 days after application. However, if applications are not made when the soil is saturated with water or when rainfall that may exceed soil field capacity is forecasted to occur within 24-48 hours, then risks to non-target plants will be reduced but not eliminated. The level of reduction cannot readily be quantified due to site-specific conditions such as field size, amount of saturation in the field at the time of the event, soil-type, hydrologic conditions, etc.

For ESA, the addition of an in-field 57 ft omnidirectional setback places the source of dicamba well within the boundaries of the treated field, allowing for some level of attenuation of dicamba runoff. This in combination with label instruction to avoid application to saturated soils, or within 48 hours of predicted rainfall events, supports for conclusion that effects off-field from runoff are not reasonably expected to occur in the 287 counties where the 57 ft setback is required.

2. Hooded Sprayer Studies

A hooded sprayer is an example of a drift reduction technology that can cover the entire spray boom and shields pesticide droplets from the wind from the height of release to a height above the crop, reducing the potential for pesticide drift. EPA received data from a limited number of field studies on bare soil and soybean crops for a particular hooded sprayer (RedBall 642E). EPA notes that these trials did not evaluate the use of other types of sprayers (alternative hooded broadcast, hooded in-row and layby sprayers) nor did they evaluate the use of a hooded sprayer over cotton crops.

In August 2017, a field deposition study (MRID 51242201) was conducted in Lubbock County, Texas to measure deposition following spray applications of a dicamba formulation (MON 54140) at a rate of 1.12 kg a.e./ha (1.0 lb a.e./A) using different application technologies and under varying environmental conditions. A spray solution of MON 54140 containing 0.25% v/v Induce® non-ionic surfactant was applied to fallow fields (bare ground or stubble less than 7.5 cm [2.95 in] in height) with three different types of spray nozzles using two different application methods at two different wind speed ranges in the presence and absence of the drift reduction adjuvant Intact® (0.5% v/v). The three types of nozzles used were: Turbo TeeJet® Induction flat spray tip (TTI), Air Induction Extended Range TeeJet® flat spray tip (AIXR), and Turbo TeeJet® wide angle flat spray tip (TT). Nozzle orifice size for each application method was selected to give the desired application rate of 16 – 17 gal/A (150 -159 L/ha) based on the travel speed for each application method. The two application methods were the Wilmar Fabrication LLC Redball® 642E hooded sprayer and an open boom sprayer equipped with the K-B Agritech, LLC Pattern Master. The targeted wind speed ranges during application were either less than 10 mph (4.5 m/sec) or greater than or equal to 10 mph (4.5 m/sec). For the Redball® 642E hooded sprayer, the application area for each tank mix/nozzle/wind speed range combination (i.e. treatment) consisted of 4 spray swaths each 240 m (787 ft) long and 12.2 m (40 ft) wide for a total spray area width of 48.8 m (160 ft) and the application speed was approximately 6 mph. For the open boom sprayer equipped with Pattern Master technology, the application area for each tank mix/nozzle/wind speed range combination consisted of two spray swaths, each 240 m (787 ft) long and 27.4 m (90 ft) wide for a total spray area width of 54.9 m (180 ft) and the application speed was approximately 10 mph. For all treatments, regardless of application method, spray drift deposition collectors were located along three parallel transects at 4, 8, 16, 30.5, 45, 60, 75, 90, 105, and 120-m downwind of the edge of the application area. Due to time constraints, weather conditions, and treatment priorities, not all of the Pattern Master treatments were conducted. Based on deposition profiles and the no observable effect rate for soybeans (2.61×10^{-4} lb a.e./A), study authors estimated drift distances ranging from 0 to 6.7 m and 11.3 to 39 m for the

Redball® hooded sprayer and Pattern Master, respectively. The EPA reviewer estimated drift distances of < 4 m and 13.8 to 105 m for the Redball® hooded sprayer and Pattern Master, respectively. It should be noted that as the treated fields were fallow fields (bare ground or stubble less than 7.5 cm [2.95 in] in height), the applications and deposition may not be reflective of dicamba over-the-top applications to soybean or cotton plants.

In 2020, data was submitted for a field deposition study (MRID 51320201) conducted in Maricopa, Arizona, to evaluate the impact of using a hooded sprayer on spray drift. A Redball® 642E (Wilmar Fabrication LLC) broadcast hooded sprayer application was made on two neighboring 10.1-acre soybean plots (840 ft x 521 ft) on 5/27/2020. Both plots were furrowed (to support irrigation) and had soybeans at ~V1 growth stage. Plot 1 was sprayed with XtendiMax With VaporGrip Technology (0.5 lb a.e./A), Roundup PowerMAX, and Intact. Plot 2 was sprayed with XtendiMax With VaporGrip Technology (0.5 lb a.e./A), Roundup PowerMAX, Intact, and VaporGrip Xtra (1% v/v). Applications were made with a 40 ft boom, with 13 swaths made to each plot. Wind speed during the application was approximately 5.4 mph. Air temperatures on application day at 0.33 m exceeded 115°F, while relative humidity was around 9%. Filter papers transects were placed in all directions (12 transects/plot) with distances ranging from 9.8 ft to 108 ft from field edge (**Figure G.1**). Based on the wind direction during the time of application, transects 3, 4, 5, 6, and 7 were considered downwind. Based on the estimated deposition curves, for all but one transect (Transect 3, Plot 2), the distance to the no observable effect rate for soybeans (2.61x10^{-4} lb a.e./A) was less than the first sample distance of 9.8 or 11 ft. For Transect 3, Plot 2, the distance to the no observable effect rate for soybeans was estimated at 20 ft.
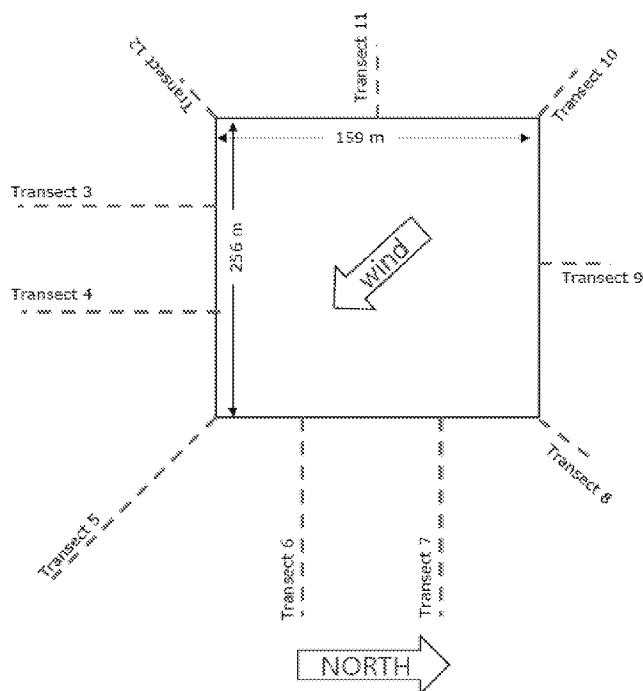
Figure G.1. Field Conditions, Hooded Sprayer Study, Maricopa, AZ

In 2020, data was submitted for a field deposition study (MRID 51320201) conducted in Rich Hill, Missouri. A Redball® 642E (Wilmar Fabrication LLC) broadcast hooded sprayer application was made on a 7.1-acre soybean plot (600 ft x 518 ft) on 8/6/2020 and included plant effects measurements in addition to drift measurements. Soybean were at V6-V7 growth stage during application (crop height ~35 cm).

The tank mix contained XtendiMax With VaporGrip Technology (0.5 lb a.e./A), Roundup PowerMAX, Intact, and VaporGrip Xtra. Applications were made with a 40 ft boom, with 13 swaths made to the field. Wind speed during the application was approximately 3 mph. Air temperatures on application day at 0.33 m was 91°F, while relative humidity during application was around 60%. Filter papers transects were placed in all directions (7 transects) radiating out from the treated field with distances ranging from 3 m to 90 m from field edge (**Figure G.2**). Transect D1, D2, and D7 were considered downwind based on wind direction during application. Plant effect measurements included visual symptomology and plant heights measured at 0, 14, and 28 days after application along 9 transects (6 uncovered and 3 tarped) at distances ranging from 3 m to 20 m for tarped transects and 3 m to 60 m for the uncovered transects. Based on the estimated deposition curves, the distance to the no observable effect rate for soybeans (2.61×10^{-4} lb a.e./A) along all transects was less than the first sample distance of 3 m (9.8 ft). Plant effects data indicated that there were no visual signs of injury or significant reductions of plant height for any transect with reported results. However, uncertainty in control data (no data provided for 2 of the 3 controls) and missing data for entire transects (i.e., DWB and UWB), as well as the lack of a formal report and metadata surrounding the potential exposure, did not allow for a full evaluation of the effects on plants for this study.
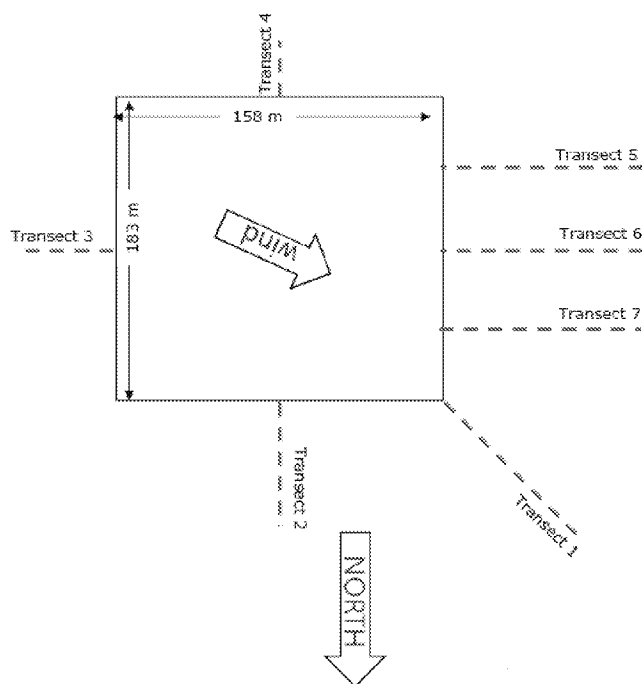
Figure G.2. Field Conditions, Hooded Sprayer Study, Rich Hill, MO

Table G.1 depicts the distances to effect from the data available from the three trials. EPA conducted a Crystal Ball analysis with this data to determine the 95th percentile distance to effect. Where the estimated distance was less than the nearest sampler, EPA used the nearest sampler distance in the analysis to be protective. **Table G.2** presents the Crystal Ball analysis results. The best fit for the data was based on a negative binomial distribution, with a 95th percentile distance to effect of 17 ft, which was rounded up to 20 ft for simplicity.

Based on the data provided for bare ground applications and an analysis of available data for applications to soybeans, the particular hooded sprayer evaluated (RedBall 642E) can reduce off-field

deposition of dicamba to approximately 20 ft from the point of application. EPA distance to effect analyses (**Appendix E**) indicated that the expected distances extend 2 to 5 times further than predicted from spray drift deposition data when compared to the NOAEL. EPA determined that a 5X safety factor would address the uncertainties with this limited set of data and the distance to effect uncertainties. Therefore, the use of this hooded sprayer would allow the 240-foot in-field spray drift buffer to be reduced to 110 feet and still be protective of non-listed plant species with a high level of confidence. EPA notes that because it does not have a formal submission of the soybean studies, it cannot evaluate elements of the studies (i.e., meteorological data, analytical data, application metadata). See **Appendix O** for discussion of the in-field downwind spray drift setback distance when using hooded sprayers in areas where listed species are present.

Table G.1. Distances to Effect from Redball Hooded Sprayer Trials

MRID	Site	Application surface	Transect	Estimated Distance to Effect(ft)	Closest Sampler Distance (ft)
51242201	TTI11003, Tmt 1	Bare soil		0.75	14
51242201	TT11003, Tmt 2	Bare soil		12	14
51242201	AIXR11003, Tmt 3	Bare soil		6.2	14
51242201	TTI11003, Tmt 4	Bare soil		0.26	14
51242201	TT11003, Tmt 5	Bare soil		3	14
51242201	AIXR11003, Tmt 6	Bare soil		4.3	14
51242201	TTI11003, Tmt 13	Bare soil		0.3	14
51242201	TT11003, Tmt 14	Bare soil		1.25	14
51242201	AIXR11003, Tmt 15	Bare soil		2.8	14
51242201	TTI11003, Tmt 19	Bare soil		2.5	14
51242201	TT11003, Tmt 20	Bare soil		3.3	14
51242201	AIXR11003, Tmt 21	Bare soil		1.6	14
51320201	MO	Soybean, V6	D1	2.02	10
51320201	MO	Soybean, V6	D2	0.041	10
51320201	MO	Soybean, V6	D3	0.68	10
51320201	MO	Soybean, V6	D4	0.26	10
51320201	MO	Soybean, V6	D5	0	10
51320201	MO	Soybean, V6	D6	0.046	10
51320201	MO	Soybean, V6	D7	0.089	10
51320201	AZ, plot 1	Soybean, V1	3	0.48	10
51320201	AZ, plot 1	Soybean, V1	4	0.31	10
51320201	AZ, plot 1	Soybean, V1	5	0.35	10
51320201	AZ, plot 1	Soybean, V1	6	4.5	11
51320201	AZ, plot 1	Soybean, V1	7	1.8	11
51320201	AZ, plot 2	Soybean, V1	3	0.33	10
51320201	AZ, plot 2	Soybean, V1	4	20	20
51320201	AZ, plot 2	Soybean, V1	5	2.5	10
51320201	AZ, plot 2	Soybean, V1	6	2.17	11
51320201	AZ, plot 2	Soybean, V1	7	2.2	11

Table G.2. Crystal Ball Analysis
Forecast: Dist

Summary:
Entire range is from -0.02 to 267.58
Base case is 1.00
After 10,000 trials, the std. error of the mean is 0.11

Statistics:	Forecast values
Trials	10,000
Base Case	1.00
Mean	3.66
Median	0.96
Mode	---
Standard Deviation	11.23
Variance	126.20
Skewness	11.41
Kurtosis	190.62
Coeff. of Variation	3.07
Minimum	-0.02
Maximum	267.58
Range Width	267.60
Mean Std. Error	0.11

Forecast: Dist (cont'd)

Percentiles:	Forecast values
5%	0.05
10%	0.11
25%	0.32
50%	0.96
75%	2.93
90%	7.83
95%	14.42
100%	267.58

End of Forecasts
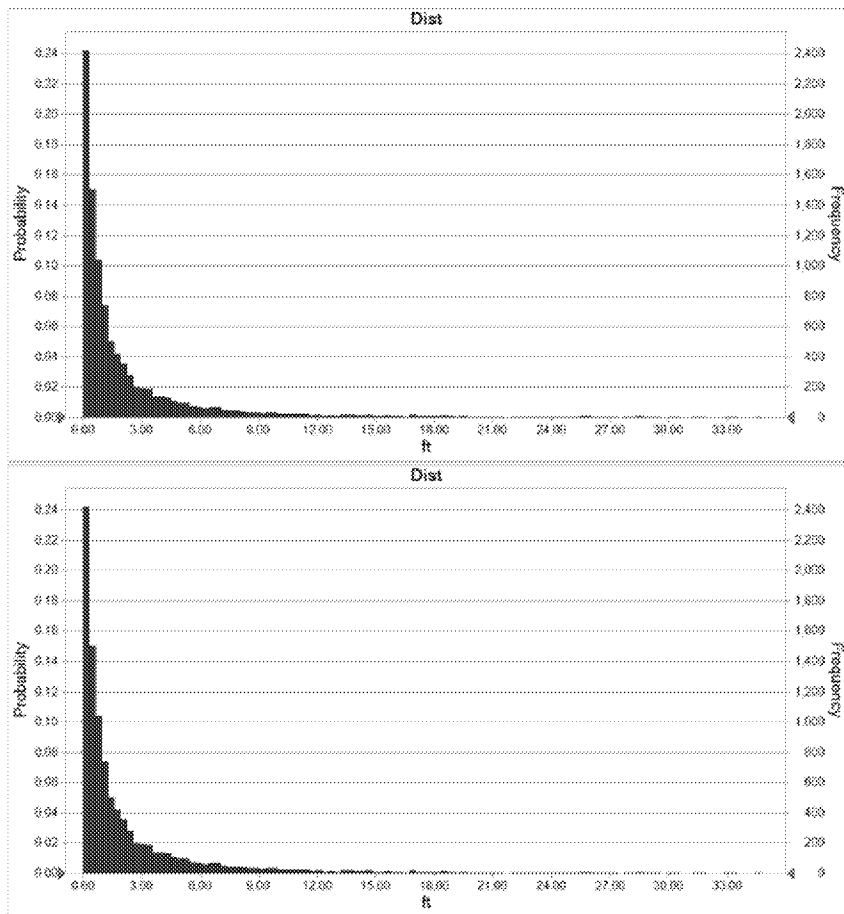
Assumption: Dist

Lognormal distribution with parameters:

Location	-0.02
Mean	3.59
Std. Dev.	12.72

Statistics:	Assumption values	Distribution
Trials	10,000	---
Base Case	1.00	1.00
Mean	3.66	3.59
Median	0.96	0.97
Mode	---	0.05
Standard Deviation	11.23	12.72
Variance	126.20	161.78
Skewness	11.41	53.98
Kurtosis	190.62	37,123.82
Coeff. of Variation	3.07	3.54
Minimum	-0.02	-0.02
Maximum	267.58	∞
Range Width	267.60	---
Mean Std. Error	0.11	---

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Assumption: Dist (cont'd)

Percentiles:	Assumption values	Distribution
5%	0.05	0.05
25%	0.32	0.31
50%	0.96	0.97
75%	2.93	2.91
90%	7.83	7.77
95%	14.42	13.96
100%	267.58	∞

End of Assumptions
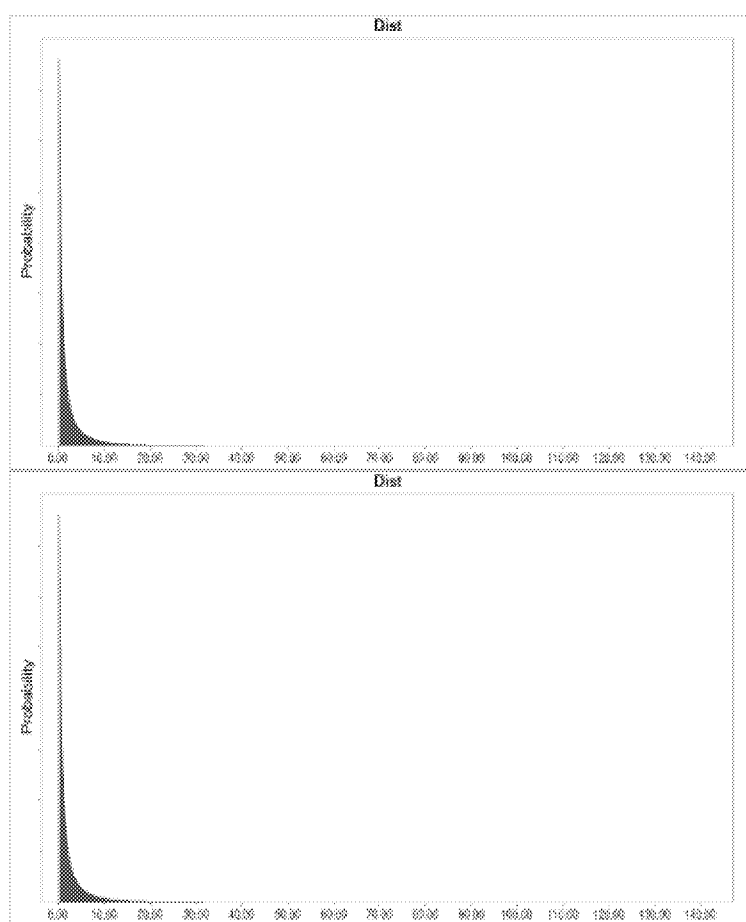
3. Open Literature

Open literature articles identified by EPA lend support to the conclusions that temperature inversions can occur in the regions where dicamba over the top applications may occur and that the control

measures on the label designed to reduce the impacts of temperature inversions (i.e., only spray between one hour after sunrise and two hours before sunset, applications can only occur when boom-height wind speed is between 3 and 10 miles per hour) are important to maintain. Additionally, late afternoon applications can result in higher emissions of dicamba and that the addition of glyphosate can increase dicamba emissions, supporting the inclusions of VRAs to the tank mix.

In 2019, research by Bish et al[34] focused on the development of inversion profiles at atmospheric heights relevant to ground applications, which typically occur 46 to 107 cm (1.5 to 3.5 ft) above ground level (AGL) and the potential adverse impacts that could occur resulting from dicamba volatility. During the 2015–17 soybean growing seasons (April through July), data were collected at three heights AGL (46, 168, and 305 cm [1.5, 5.5, and 10 ft]) in three soybean producing regions of Missouri (Albany, Columbia, and Hayward) to characterize inversions. Inversions were classified as occurring if (1) air temperatures at 305 cm and 106 cm were greater than air temperatures at 46 cm, (2) temperatures remained inverted for more than 1 hour in duration, and (3) the air temperature difference between 46 and 305 cm exceeded 1.3°C at some point during the event. Over 600 inversions were characterized by the study authors, all of which were nocturnal in nature. Inversions typically lasted overnight at two locations, with the duration varied at the third location. The largest temperature difference recorded was 68°C. Based on the number of inversions presented in the report, the number of inversions per month appeared to decrease for two of the sites as the date moves from April to July. For the third site, Albany, the number of inversions appeared to remain stable from April to June, but then decreased dramatically in July. This appeared to make sense, for as the date moved from spring to summer, the temperature increased and the length of the daylight increased, decreasing the opportunity for temperature inversions to occur during daylight hours. For two of the sites, Albany and Columbia, the median duration of inversions appeared to decrease as the date moved from April to July, while the median duration at the Hayward site appeared to remain stable during April to July, varying between 11.5 to 13 hours. The median start time of inversions tended to occur at later times at all three sites as the date moved from April to July and the median end time at two of the sites (Albany and Columbia) occurred earlier as the date moved from April to July while the end time at the Hayward site remained steady. Study authors posited that the stability of inversion duration at Hayward could be the result of obstacles around the site sheltering the site, reducing wind speeds and vertical mixing. As a result of the findings from this research, temperature inversions in soybean growing areas occurred between sunset and sunrise and have the potential to contribute to the offsite effects of dicamba.

In 2019, Bish et al[35] investigated the impact of application timing on the volatilization of dicamba. High-volume air samplers were used to determine concentrations of dicamba in air after treatment to soybean. In the first set of experiments, the dicamba formulations XtendiMax and Engenia were applied to soybean. Applications were made at the same time with treated areas at least 480 m apart to avoid cross-contamination. Dicamba was applied at the labeled rate of 560 g a.e./ha and included 840 kg a.e./ha glyphosate potassium. Similar levels of dicamba were detected for both formulations, and the highest amounts (22.6 to 25.8 ng/m3) were detected in the first 8 h after treatment (HAT). A second set of experiments involved comparisons of afternoon applications, when the atmosphere was unstable, to evening applications under stable atmospheric conditions. Dicamba detected in the first 8 HAT was

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[34] Bish, M., Guinan, P., Bradley, K. 2019. Inversion Climatology in High-Production Agricultural Regions of Missouri and Implications for Pesticide Applications. Journal of Applied Meteorology and Climatology, 58: 1973-1992
[35] Bish, M., Farrell, S., Lerch, R. Bradley, K. 2019. Dicamba Losses to Air after Applications to Soybean under Stable and Nonstable Atmospheric Conditions. Journal of Environmental Quality doi:10.2134/jeq2019.05.0197

nearly threefold higher in applications made under stable atmospheric conditions (i.e. late afternoon applications). All experiments resulted in detection of dicamba through the last time point 72 HAT, indicating that volatility occurred regardless of application timing or formulation. Applications that included glyphosate resulted in higher dicamba concentrations than applications lacking glyphosate. In short, emissions of dicamba increase dramatically when dicamba is applied in the later afternoon, can last more than 3 days, and increase with the addition of glyphosate to the tank mix.

Appendix H. Evaluation of Volatility Reducing Agents

To address volatile emissions, particularly those that are the result of tank mixes where the pH of the mixture drops below 5 and the potential for dicamba emissions increases, the label requires volatility reducing agents be used with all approved tank mixes. The following describes the laboratory studies conducted to evaluate the efficacy of these VRAs (buffering agents) to reduce volatile emissions. In general, the use of VRAs can reduce volatilization of dicamba from tank mixes applied to treated soil and soybean fields.

1. Humidomes

1.1. Vaporgrip X

In a series of laboratory studies (MRIDs 51242202-06) conducted from May to July 2020, the relative dicamba volatility of 133 tank mixes of dicamba products and other products, with and without Vaporgrip X (a volatility reducing agent), was investigated on uncharacterized soil (50% Redi-Earth and 50% US10 field soil mix) under aerobic soil conditions at 35ºC and a relative humidity level of 40% for a period of 24 hours. Three replicates for each tank mix were examined in the study. Polyurethane foam (PUF) samples were collected for 24 hours after treatment at a uniform flow rate of 1.85 L/minute. The PUF samples were extracted using methanol, and dicamba was quantified using LC-MS/MS. A comparison of the reduction in the average flux rates of the 133 tank mixes with and without Vaporgrip X indicated that, for 125 tank mixes, reductions in average flux ranged from 11 to 100%. Study authors excluded the results from eight combinations because the mean dicamba air concentration without Vaporgrip X was below 2xLOQ. For three of those eight combinations (XtendiMax+LoKomotive, XtendiMax+Megafol, and XtendiMax+Voyagro), the EPA reviewer estimated that the reduction was 0%. For two of the combinations (XtendiMax+Revival and XtendiMax+N-PactK12-0-12), the EPA reviewer estimated that there was an increase in the flux rate of 16 and 68%. For the remaining three combinations (XtendiMax+Katalyst0025, XtendiMax+NovusK, and XtendiMax+DeliveredKPlus), the EPA reviewer estimated that the reduction was 0.13 to 9%. It should be noted that only 35 of the 133 tank mixes included PowerMAX (glyphosate), a common tank mix with dicamba products. PowerMAX has been shown to reduce the pH of dicamba tank mixes and increase the volatility of dicamba. In trials with XtendiMax, average concentrations increased from 7.5 ng/m^3 to 969 ng/m^3 when PowerMAX was added to the tank mix. As a result, it is uncertain how the volatility of the 98 tank mixes without PowerMAX would perform if PowerMAX were included in the tank mix.

1.2. BASF Volatility Reducing Agent

In a laboratory study (MRID 51279701), the relative dicamba volatility of Engenia with and without a VRA (buffering agent; 4 fl oz/A, 0.18 lb/A) was investigated on partially characterized soil (50% sandy loam soil and 50% Redi-Earth & Seedling Potting Mix) under aerobic soil conditions for a period of ca. 24 hours with various tank mixes (PowerMAX and Liberty) and varied temperatures (30-35°C and 40-45°C) at ambient relative humidity (ca. 40%). Soil samples were treated at a target application rate of ca. 0.56 kg a.e./ha (0.5 lb a.e. dicamba/A). Four replicates for each test condition were examined in the study. Mixed Cellulose Ester (MCE) filter samples were collected for 24 hours after application at a target flow rate of 2.00 ± 0.10 L/minute. The MCE samples were extracted using methanol then centrifuged or filtered to eliminate precipitate, and dicamba was quantified using LC-MS/MS. No analyses of dicamba in soil were performed. The mass of dicamba collected on the sorbent material was generated for each

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replicate. A comparison of the tank mixes with Engenia with (BAS 183 35H) and without a VRA indicated that, for the two temperature ranges and the two tank mix products (PowerMAX and Liberty), tank mixes with the VRA had less volatilization than those without the VRA (buffering agent). It should be noted, though, that when the temperature increases to 40-45°C, the emissions with the VRA are comparable to the emissions of the tank mix without the VRA at 30-35°C, indicating that applying at a lower temperature is just as effective as at reducing emissions as applying at a higher temperature with a VRA. Based on the submitted data, there does not appear to be any benefit to adding the VRA when Engenia is applied by itself. That being said, there is no need to add a VRA to the product alone, as there is nothing in the tank mix that can increase the volatility of the dicamba.

2. Off-field Movement Studies

All off-field movement studies are discussed in **Appendix E**.

Appendix I. Incident Informed Evaluation of Temperature and Cut-Off Date for Controlling Volatility

1. Zones of Potential Impact

The effects of dicamba exposure to organisms outside the herbicide-treated field area can be divided into three zones of possible impact: on-field, near-field, and wide area. With regards to evaluating volatility, EPA focused on near-field and wide area impacts.

1.1. Near-field Zone of Impact

The first zone is most accurately termed the near-field zone of impact. This is the area surrounding the treated field that may receive dicamba exposure via the drifting of spray droplets during and immediately after application (spray drift) and, to some additional extent, exposure to vapor phase dicamba which volatilizes from the treated field under favorable environmental conditions over more protracted time periods (vapor drift). Available distance to effect studies from the dicamba registrants and the academic researchers support a general finding that spray drift is the dominant exposure route in the near-field zone. However, these same field studies do support that dicamba vapor drift does occur and that the near-field zone does receive exposure via this route.

The available field studies and the Agency's spray drift modelling tools and available vapor phase dispersion tools provide reasonable confidence in describing the distance to effects in this zone out to between 300 to 400 feet from the field edge, depending upon the nature of the exposure route (spray droplet drift vs vapor phase transport). These same tools allow for evaluation, to a certain degree, of the efficacy of spray droplet drift mitigations and to a lesser degree of confidence the vapor-phase route of exposure. With respect to establishing confidently protective spray drift and vapor phase setbacks as a mitigation, it is apparent from the Agency's current analyses of incidents and field studies, that relying solely on this mitigation option has had variable success under varied field conditions. Moreover, that variability would necessitate quite large setbacks if setbacks were the only mitigation measure applied, potentially impacting field productivity and creating areas for development of weed resistance.

1.2. Wide Area Zone of Impact

The wide area zone of impact may most reasonably be defined as the area where dicamba-related plant damage has been observed to occur over distances beyond which existing field studies and modelling tools have quantified distances to effects. Wide area effects are by their nature difficult to attribute to a particular source, and EPA cannot rule out the possibility that they may be caused in part or in whole by dicamba products other than the products registered for use on DT crops.

Available field studies **Appendix E** have documented situations where dicamba-consistent signs of plant symptomology were observed to occur that were unrelated to the field study applications of the herbicide. In one study (MRID 50958202) the sensitive soybean test plot was replanted owing to dicamba symptomology that was from undetermined off-site sources. Given the observations of symptoms across the field, it was reasonable to expect that the dicamba source was beyond the field boundaries by 1000 ft or more.

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The largest body of evidence for such wide area effects originates in the registrants' FIFRA Section 6a(2) reports of dicamba incidents. (See Section 1.7. in main document). As described there, there are some 5600 such incidents (reported at various distances) for the years 2017 through 2019. The available reporting data show incidents have occurred well beyond predicted distances from treated fields even under label restrictions regarding spray drift and vapor drift setbacks designed to address these routes of exposure.

The Agency has taken a closer look at the available incident data in the process of the current FIFRA risk/benefit assessment as well as in the effects determinations under the ESA (**Section 1.7**).

Wide-area incidents occurring at distances of hundreds of feet from a dicamba use site are not likely the result of spray drift. EPA's spray drift analysis tools have been scientifically vetted and accepted and other mitigation measures (droplet size, spray height, DRAs, temperature inversion advisory language, and windspeed restrictions) are reasonably expected to prevent spray drift beyond the predicted distances for GMO soybean and cotton. However, vapor phase exposure, especially on large landscape scales beyond the 10 to 20-acre field scale used for distance to effects fields studies submitted by registrants and academics, is not well modelled with existing tools. So, the possibility of vapor phase drift causing adverse effects in the wide area zone cannot be definitively excluded.

2. Evaluation of Application Cut-off Date to Address Volatility on the Near Field and Wide Area Scales.

Having additional control measures in place provides for more confidence in avoidance of dicamba effects off the field under varying conditions. Among the multiple control measures focused on addressing volatile transport is a requirement for an application cut-off date. The labels contain a requirement for cut-off dates for dicamba application. For soybean the cut-off is June 30th across the 34 states registered for use. For cotton, cut-off date on the labels is July 30th, again applicable in all of the 34 states registered for use. These dates represent a hard cut-off of applications of the dicamba products associated with this regulatory action with the window extending from a start time at crop planting (regionally and environmentally dictated) to the cut-off date.

EPA evaluated how these cut-off dates address both near-field and wide area dicamba volatility concerns. To conduct this evaluation, EPA focused on the relationship between the cutoff dates and air temperature, an important determinant of the volatility of any semivolatile compound, including dicamba. This evaluation relied on several lines of evidence:

1. laboratory humidome data relating air temperature to rate of volatilization;
2. the effects of the above humidome findings on field-level flux rates with attendant modelling comparison of off target field (OTF) distances to selected environmental concentrations,
3. an analysis of incident data relative to select temperature thresholds; and
4. a comparison of select temperature thresholds to the meteorological record of geographically representative data sets bounded by crop planting dates and mitigation measure dicamba application cut-off dates of June 30 and July 30 for soybean and cotton, respectively.

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3. Humidome Data on Temperature Effects on Dicamba Volatility

EPA's goal for this line of evidence was to describe the relationship between the temperature in the humidome chamber and the reported rate of volatility for the variety of humidome studies available to EPA. This line of evidence pertains directly to the physical loss of dicamba via volatility from treatment areas. Steps to reduce volatility can reduce emissions impacting both the areas adjacent to the treated field (near-field zone) and, if reduced over large areas of application, will also reduce wide-area zone exposure to dicamba.

EPA analyzed the humidome data (MRIDs 51017509 and 51049001 for XtendiMax and Engenia, respectively) and developed regressions for the 24-hour average flux rates versus the 24-hour average temperature to evaluate how flux decreased with temperature, regardless of humidity. **Figure I.1** and **Figure I.2** were derived from the XtendiMax and Engenia humidome experiments, respectively. Decreasing the 24-hour average temperature from 85°F (29.4°C) to 80°F (26.7°C) resulted in a 32% and 28% reduction in flux for XtendiMax and Engenia, respectively. Decreasing the 24-hour average temperature from 85°F (29.4°C) to 75°F (24°C) resulted in a 54% and 49% reduction in flux for XtendiMax and Engenia, respectively. Decreasing the 24-hour average temperature from 85°F (29.4°C) to 70°F (21°C) resulted in a 70% and 65% reduction in flux for XtendiMax and Engenia, respectively. As the Illinois Engenia trial was the only study done at a 24-hour average temperature below 80°F (76°F) and the distance to effects had been reduced to the edge of the field for the other two studies, only the impact of decreasing the 24-hour average temperature from 76°F (24.5°C) to 70°F (21°C) for Engenia, resulting in a 35% reduction in flux, was evaluated.

The results of this analysis indicate that the volatility of dicamba is affected by ambient temperature. While the regression coefficient (**Figures I.1** and **I.2**) from the analysis between volatility and temperature are not ideal, the principle that volatility is affected by temperature is sufficiently established to use the relationships in the analysis.
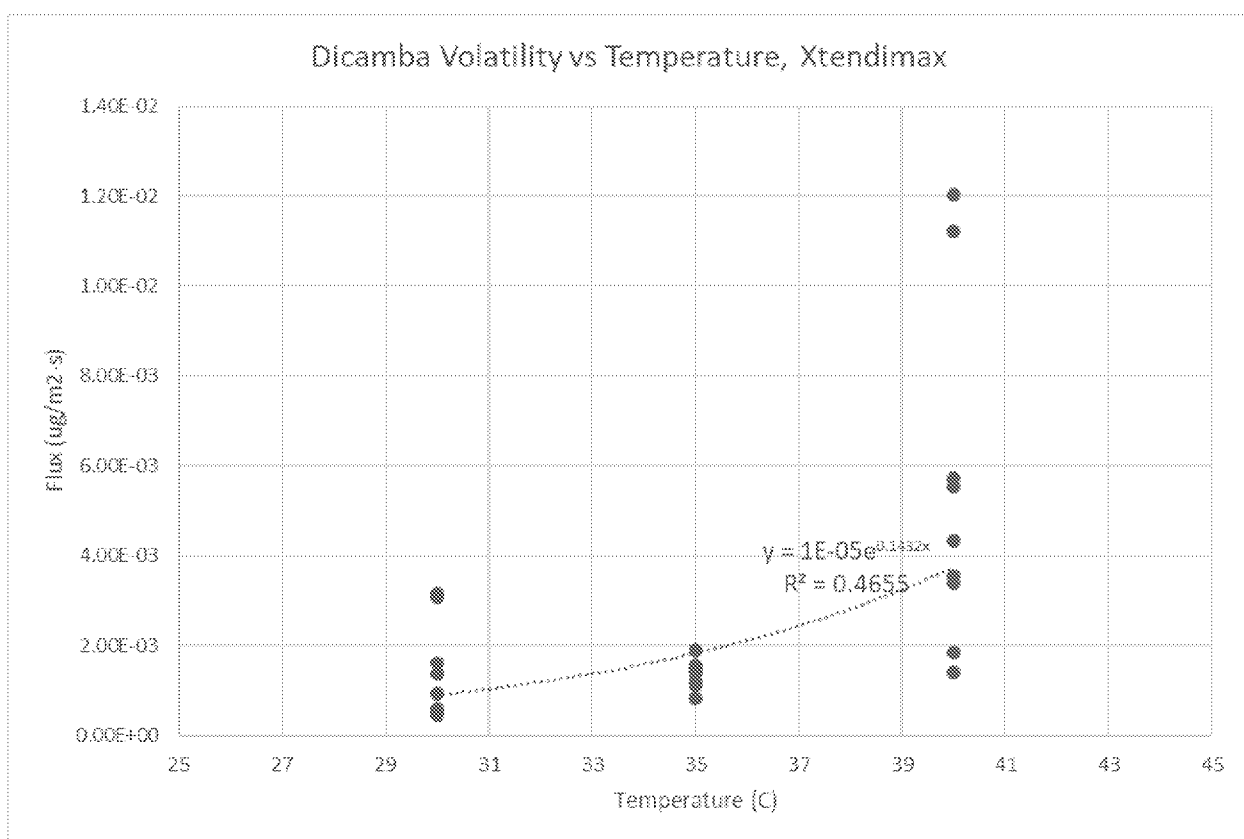
Figure I,1. Humidome Analysis of Flux versus Temperature, XtendiMax
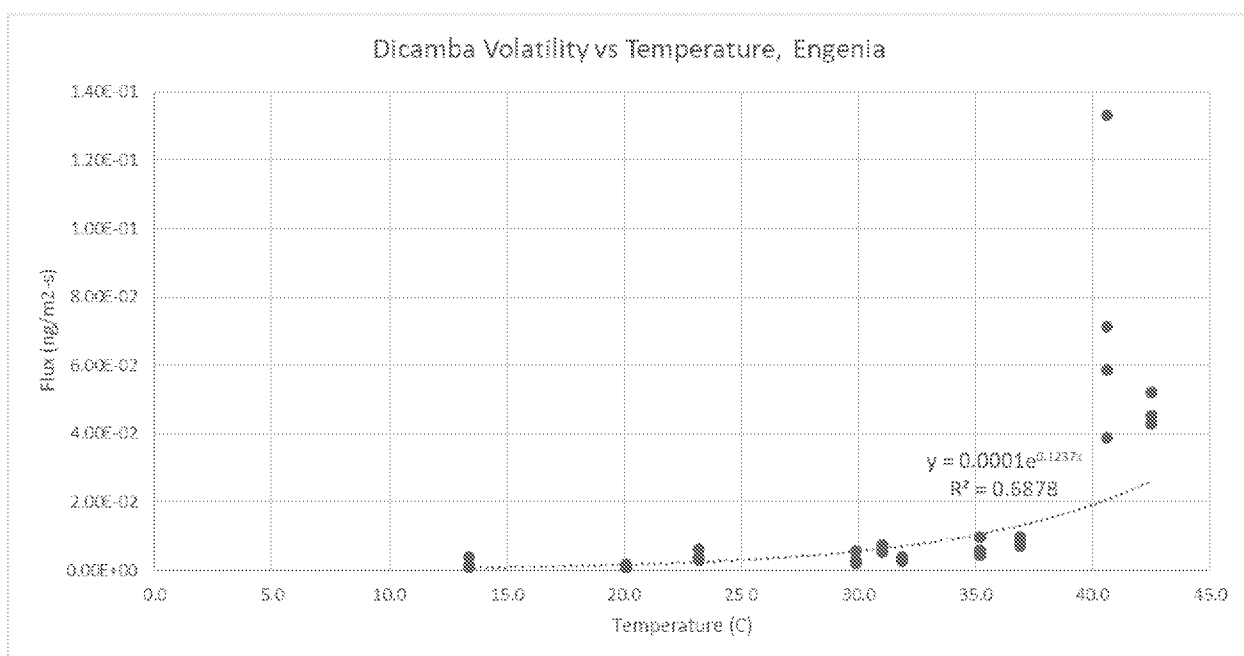
Figure I.2. Humidome Analysis of Flux versus Temperature, Engenia

4. Effects of Humidome Data on Field Level Flux Rates and Distances to Selected Environmental Concentrations of Dicamba

EPA used this line of evidence to describe how temperature-related changes in the volatility rate inform how field-level volatile flux changes in relation to temperature. This could then be used in conjunction with near field volatile transport modeling to demonstrate how temperature can result in changes in near-field exposure.

4.1. Establishing Effects Associated Air Concentrations

Of the nine dicamba field trials that were submitted as part of the 2018 conditional registration, three of the studies, the Mississippi XtendiMax, Misssissippi Engenia, and Illinois Engenia, (MRIDs 51017501, 51049003, and 51049004, respectively) had sufficient data quality for use in evaluating the distance to effects. Using the field dimensions and orientation, meteorological conditions, and flux rates from the three dicamba field trials, EPA used AERMOD (version 19191) to model the 24-hour average air concentrations for the first 24-hours along the tarped plant transects where 5% plant height reduction or 10% VSI was estimated. Using the distance to the effect (DTE) for the plant effects endpoint estimated from the tarped plant bioassay data for the field trials, EPA evaluated where the 24-hour average Effects Associated Air Concentration (EAAC) for the different tarped transects crossed the DTE. Below is a discussion of the results.

4.1.1. Mississippi XtendiMax (MRID 51017501)

Figure I.3.**Figure 1.3** depicts the results for the Mississippi XtendiMax modeling. The three tarped downwind (DW) transects (DWA, DWB, and DWC) generated the maximum concentrations (solid lines). The dotted vertical lines (DWA/DWB DTE) depict the respective distance-to-effect (DTE) for tarped transects DWA and DWB; the plant data for tarped DWC was omitted due to plant injury that the study authors attributed to heat stress from being under the tarps. For all three tarped DW transects, the EAAC where the DTEs intersect the curves are around 5-5.5 ng/m^3. DTE are also available for the right wind (RW) tarped transects, indicating a lower EAAC of 2-4 ng/m^3. It should be noted that there was a very low impact on plant height and 10% VSI or less in the RW area. As a result, there was no strong distance response with VSI but rather the regression was satisfactory for estimating the distance to 5% height reduction.

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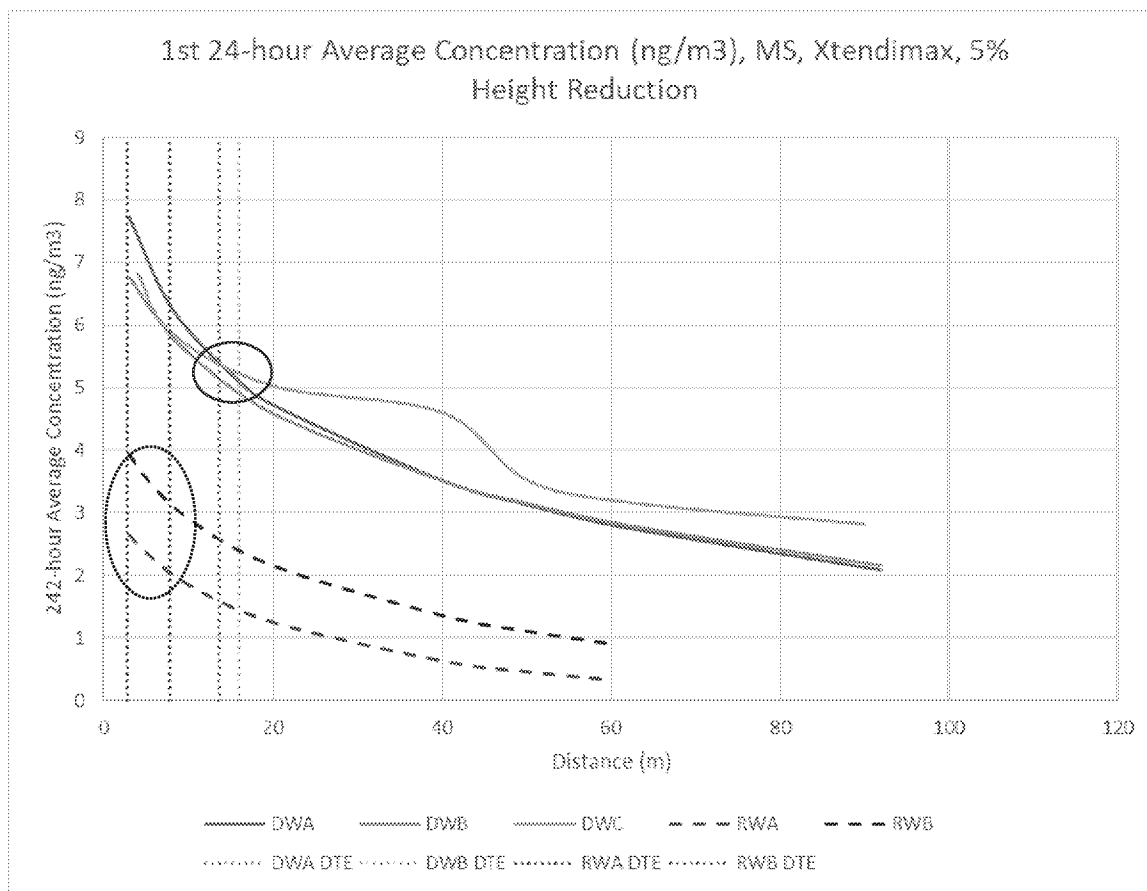
Figure I.3. AERMOD Modeling Results for Mississippi XtendiMax Trial

4.1.2. Mississippi Engenia (MRID 51017501)

Figure I.4.**Figure 1.4** depicts the results for the Mississippi Engenia modeling. The three tarped downwind transects (DWA, DWB, and DWC) generated the maximum concentrations, the dotted vertical lines depicting the respective DTE for each tarped transect. In all three cases, the EAAC where the DW tarped transects intersect their DTE is between 4.6 ng/m^3 and 6 ng/m^3. DTE are available for other tarped transects (LWA and LWB) and tend to be further away from the field (~ 40 m). In this trial there were no reductions in plant height, but there was a 30-45% VSI, such that the DTEs for 10% VSI could be developed through regression. For these tarped transects, the range of EAACs at the DTE is approximately 0.1-0.25 ng/m^3.

1st 24-hour Average Concentration (ng/m3), MS, Engenia, 10% VSI

Legend: DWA, DWB, DWC, LWA, LWB, DWA DTE, DWB DTE, DWC DTE, LWA DTE, LWB DTE
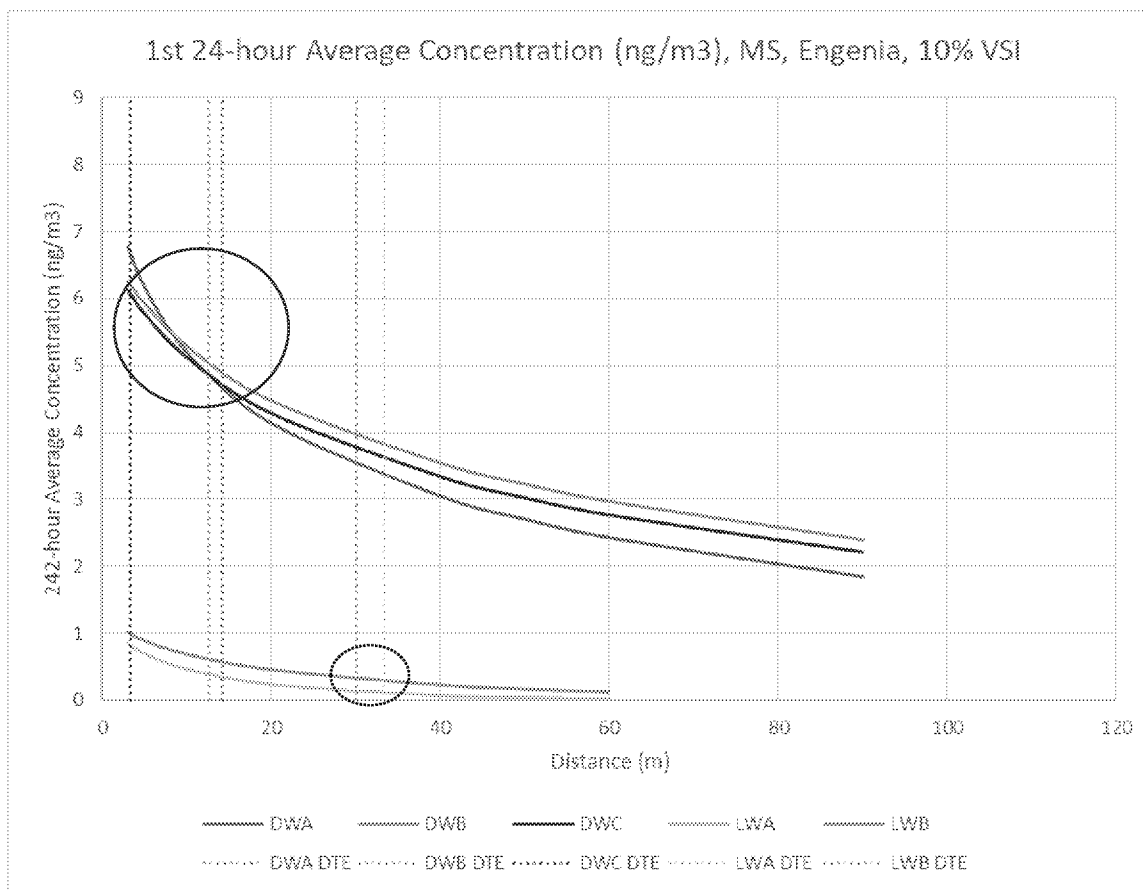
Figure I.4. AERMOD Modeling Results for Mississippi Engenia Trial

4.1.3. Illinois Engenia (MRID 51049004)

Figure 1.5 depicts the results for the Illinois Engenia modeling (note that DWB and DWC are identical and appear as one line in the graph). In this case the DTE for all three downwind tarped transects were less than or equal to 3 m, such that the dotted vertical lines depicting the respective DTE for the three downwind tarped transects appear as one line. In all three cases, the DW tarped transects intersect their DTE between EAACs of 3 and 5 ng/m^3. The air concentrations estimated for the left wind tarped transects (LWA/LWB) were much lower than those estimated for the downwind tarped transects but generated much larger DTE ($\geq$ 10 m). The EAACs at the DTE for these tarped transects is approximately 0.3-0.4 ng/m^3. It should be noted that all of the tarped transects had very low plant effects. 10 VSI was nor observed along any of the tarped transects.

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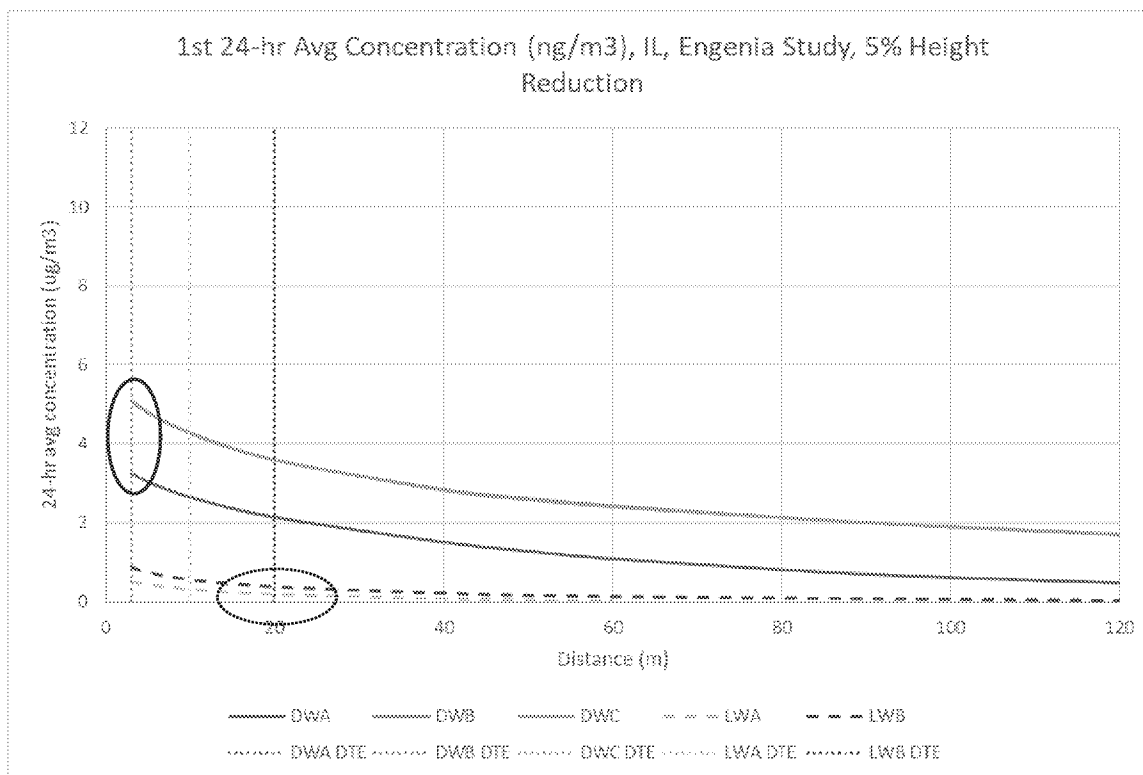
Figure I.5. AERMOD Modeling Results for Illinois Engenia Trial

4.1.4. Conclusions

The Mississippi XtendiMax and Engenia trials, as well as the Illinois Engenia trial, appear to provide a 24-hour EAAC of approximately 3-5 ng/m3 for the downwind tarped transects 24 hours after application, such that the data can be used to evaluate the impact of reductions in temperature on distances to effect. These concentrations match up well with the in-field volatility toxiticy data generated by Norsworthy in 2019 (see **Appendix C.7.2**)

4.2. Analysis of Distance to Effect, Reducing Flux Using Humidome Data

From the three field studies discussed above (Mississippi XtendiMax, Mississippi Engenia, and Illinois Engenia), EPA determined that the average 24-hour average air concentration of dicamba associated with a 5% reduction in height or 10% VSI is 4 ng/m^3.

The humidome-derived temperature vs volatility regression functions established in the humidome data analysis step were used to establish temperature-based scaling factors for field flux rate, reasoning that field flux rate would track the change in dicamba volatility rate as temperature changes. These factors were applied to the flux rates from the field studies to evaluate the impact on the distance EAAC for each field study, assuming the 24-hour average concentration was representative of the peak emission period for dicamba volatilization. The data are presented in **Table I.1.** For the MS XtendiMax and Engenia studies, if the temperature were 80°F, the scaled distances to effect range would range from 7 to 10 m (23 to 33 ft). If the temperature were 75°F, the scaled distance to effect would be 0 m. For the Illinois Engenia study, the 24-hour average temperature was 76°F and distances to effect were ≤ 3 m. If the temperature was 70F, the scaled distances to effect would be 0 m.

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Table I.1. Effect of temperature on distance to effect

Field Trial	24-hour avg temperature	Transect	Estimated Distance to Effect (m)	Estimated Distance to Effect (m), 80°F	Estimated Distance to Effect (m), 75°F	Estimated Distance to Effect (m), 70°F
MS XtendiMax	85°F	DWA	14	10	0	0
		DWB	16	7	0	0
MS Engenia	85°F	DWA	14.2	7	0	0
		DWB	12.6	7	0	0
		DWC	3.4	7	0	0
IL Engenia	76°F	DWA	3	NA	NA	0
		DWB	< 3			0
		DWC	< 3			0

Distance to Effect at 80°F was determined using 4 ng/m3, which was the typical concentration at the distance to effect in the studies. Distances to effect were based on 5% plant height reduction in the MS XtendiMax and IL Engenia studies and 10% VSI for the MS Engenia study.

4.2.1. The conclusions drawn from this step of the analysis include:

1. the humidome-observed reductions in volatility with reduced ambient temperature can be used to inform the extent to which changes in temperature conditions could flux rate of dicamba under field conditions

2. ambient air temperature, evaluated in terms of changes in field-scale flux emissions of dicamba, shows that dicamba emissions of dicamba from treated fields can be reduced with decreasing ambient temperature

3. If dicamba applications are limited to periods where air temperature is 80F or less, air concentrations associated with observed plant effects thresholds can be limited to within the margins of the treated field

4.2.2. The uncertainties and assumptions associated with this analysis include:

1. Scaling of flux rates using 24-hour average temperatures does not account for the diurnal/nocturnal nature of the flux rate. Rather it assumes that a similar decrease will occur in the night hours, when temperatures are cooler and less dicamba is emitted, as will occur in the daytime hours, when temperatures tend to be hotter and will result in more dicamba being emitted.

2. As a result, the scaling may underestimate the emissions occurring during the day and overestimate the emissions occurring during the night.

3. The treated fields were approximately 20 A in size. It is uncertain if the same impact would occur at larger field sizes.

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5. Analysis of Incident Data Relative to Select Temperature Thresholds

EPA quantified the effect of temperature thresholds evaluated in the above steps on the frequency of incidents that might have been avoided, if the thresholds were considered as "spray or no spray" criteria. In order to consider incidents for this evaluation EPA established the following data criteria for inclusion of an incident in the analysis:

1. A reported incident must have a reported application date for the incident
2. The incident must have reported latitude and longitude coordinates
3. The incident must have a reported distance from spray to affected site

These criteria enabled EPA to establish proximity of an incident to the alleged source site of dicamba and use the associated application data to compare with geographically maximum temperature data on the reported day of application.

Within two FIFRA 6(a)(2) submissions, "Bayer Off Target Movement (OTM) Inquiries" and "BASF Off-Target Reports", EPA searched the ~5600 incidents reported as occurring in 2017, 2018, and 2019 for those that reported dicamba application location, date, and the distance from that application to the reported incident .Out of the nearly 5600 6(a)2 incidents reported, a subset included sufficient information to allow EPA to establish a distance from a suspected dicamba use site to the affected plants. A total of incidents 493 provided this information. The extreme spread of distances from suspected application site to incident ranged from the treated field edge (0 feet) to 8,089 feet. EPA selected all incidents that occurred 50 feet or beyond the reported dicamba source site. Fifty feet was selected as this approximated the outer limit of the 57-foot omnidirectional buffer that was on the labels to mitigate volatile emissions. Two-hundred and seventy-nine (279) incidents occurred beyond the assigned volatility buffer distance.

EPA identified the nearest weather reporting station with temperature and humidity data for the day before, the day of, and the day after the incident (Weather Underground) for each of the 279 incidents. EPA then extracted from the weather records at each station the maximum temperatures for the day before, the day of, and the day after the incident's reported date of application. In situations where a dicamba application was reported in the incident data as spanning multiple days, EPA gathered temperature data for the day before the first phase of application through the day following the final phase of the application. EPA selected the maximum air temperature on the day(s) of application or days of application and evaluated those reported temperatures relative to four selected temperatures: 70, 75, 80 and 85°F.

EPA then recorded the number and percentage of incidents reported with site application maximum temperatures $\leq$ and > X°F. The results of that analysis are included in **Table I.2.**

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Table I.2. Incident Number and Percentages Associated with Maximum Daily Temperature Categories (N=279)

Temperature °F	Number of Incidents	Percentage of Incidents (rounded to whole number)
≤70	6	2
>70	273	98
≤75	18	6
>75	261	94
≤80	50	18
>80	229	82

The results in **Table I.2** can be used to inform the percentage of applications that likely would not have occurred if the label prohibited dicamba application of dicamba when temperatures were above 70, 75, 80 °F). As shown, 98%, 94%, and 82% of the applications leading to a reported incident 50 feet or greater from the application site would likely have been prevented with a labelled temperature cut-off of 70, 75, and 80°F, respectively.

5.1. The uncertainties and assumptions associated with this step in the analysis include:

1. Assignment of a dicamba application event to each incident in the analysis may not address the closest source of dicamba and other contributions to dicamba exposure may not be limited to the assigned site of herbicide use.
2. Volatility may not be the only source of dicamba exposure and so temperature at time of application my not always be an important discriminator for the dicamba exposure related to the incident
3. Other meteorological factors such as wind speed, direction, and the formation of temperature inversion conditions can play a role in the extent to which volatilized dicamba is transported and distributed in vertical strata of the near-ground atmosphere.

6. Comparison of Selected Temperature Thresholds to the Meteorological Record of Geographically Representative Data

EPA evaluated how cut-off dates of June 30th for soybean and July 30th for cotton performed relative to the proportion (or probability) of days where possible dicamba application could occur on those crops would potentially occur on days at or above selected temperature thresholds.

The previous steps in this analysis suggested that dicamba volatile emissions and correspondingly dicamba air concentrations associated with observable plant effects can occur off the treated field at temperatures above 75 °F. Moreover, a majority of dicamba incidents in the incident analysis occurred at application temperatures above 75 °F. Therefore, EPA used the temperature levels of 75 and 80 °F to conduct this phase of the analysis.

EPA consulted the Biological and Economic Analysis Division (BEAD, personal communication Bill Chism, Johnathan Becker, and Kelly Tindall) for information on state-specific crop planting dates for soybean and cotton, which were used as the beginning dates of the application window. The closing dates of the application window were the soybean and cotton labeled cutoffs for application, June 30th and July 30th, respectively.

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For each of the 34 states labeled for product(s) use, EPA identified a geographically representative Pesticide in Water Calculator (PWC) crop scenario and attendant meteorological data files that has been developed for EPA routine ecological risk assessment modelling.

From each meteorological data file, EPA extracted 35 years (1980-2014) of the scenario's daily maximum temperatures within the windows described by each state/crop planting date and the crop specific cut-off date. EPA then calculated the proportion of total days equal to or greater than as well as less than 75, and 80°F. These proportions represent the probability of a dicamba application falling or not falling upon a date where temperature would be favorable, to varying degrees, for off field movement of dicamba in air and concentrations associated with observable plant effects. **Tables I.3** and **I.4** present the results of this analysis for soybean and cotton.

The analysis shows that the probability of application on a random day when the maximum temperature would occur under favorable temperature varies among different states. The conclusions regarding cut-off date performance can be divided into 1) the potential near field reductions in volatile emissions associated with observed off the field plant responses for field studies, and 2) mitigation performance for concerns for wide area volatile exposure potential including incidents at distance.

Conclusions for cut-off date avoidance of daily temperature conditions suggestive of a potential for near-field plant effects as observed in the available field studies can be reached using the 80 °F exceedance probabilities, the temperature point where available air modelling shows that field flux levels have been lowered to the extent that distances to EAAC levels have been brought back close to the field margin. The soybean cut-off of June 30th results in variable state success probabilities from a low of 12% in Texas to a high of 89% in Minnesota. Interstate variability of success probabilities is evident for the cotton cut-off date of July 30th, ranging from a low of 8% in Florida to a high of 66% in Virginia. These probabilities demonstrate that the soybean and cotton cut-off dates have the ability to provide potential reduction in the probability of random dicamba applications on days when temperatures are unfavorable for reducing dicamba flux emissions and off field transport.

Conclusions for cut-off avoidance of daily temperature conditions suggestive of a potential for wide area exposures can be reached using the 75 °F exceedance probabilities, the temperature point where available air modelling shows EAAC levels departing from the treatment field margin. For soybean the probability of avoiding an application within cut-off windows at the 75 °F level or higher ranges from a low of 3.2% in Texas to a high of 72% in Minnesota. Similar ranges in the probability of avoiding 75 °F days of application are seen with cotton with a low of 0.3% in Florida and a high of almost 36% in Virginia. These ranges in probabilities represent the potential for avoiding an application within the dicamba application window where temperature would not exceed temperatures modeled to result in dicamba EAAC levels beyond the margins of the field. This conclusion is further supported by the high probability of incident avoidance (94%) at the 75 °F level.

Table I.3. Proportion of Days Where Soybean Dicamba Application Could Occur Below and Above Select Temperature Levels.

State	Date Window		75 Degree		80 Degree	
	Start	End	% of days <75F	% of days >=75F	% of days <80F	% of days >=80F
ALABAMA	17-May	30-Jun	5.3%	94.7%	33.0%	67.0%
ARKANSAS	19-Apr	30-Jun	20.0%	80.0%	47.9%	52.1%
DELAWARE*	31-May	30-Jun	N/A	N/A	N/A	N/A
GEORGIA	10-May	30-Jun	11.0%	89.0%	45.6%	54.4%
ILLINOIS	10-May	30-Jun	43.5%	56.5%	75.9%	24.1%
INDIANA	10-May	30-Jun	43.9%	56.1%	75.8%	24.2%
IOWA	10-May	30-Jun	53.6%	46.4%	79.3%	20.7%
KANSAS	10-May	30-Jun	22.9%	77.1%	40.5%	59.5%
KENTUCKY	10-May	30-Jun	36.4%	63.6%	73.4%	26.6%
LOUISIANA	5-Apr	30-Jun	29.7%	70.3%	58.7%	41.3%
MARYLAND	7-Jun	30-Jun	21.7%	78.3%	53.9%	46.1%
MICHIGAN	17-May	30-Jun	62.6%	37.4%	78.9%	21.1%
MINNESOTA	10-May	30-Jun	71.9%	28.1%	89.2%	10.8%
MISSISSIPPI	12-Apr	30-Jun	17.4%	82.6%	44.7%	55.3%
MISSOURI	10-May	30-Jun	30.2%	69.8%	63.9%	36.1%
NEBRASKA	10-May	30-Jun	40.4%	59.6%	58.9%	41.1%
NEW JERSEY	7-Jun	30-Jun	31.1%	68.9%	61.8%	38.2%
NEW YORK	14-Jun	30-Jun	69.6%	30.4%	86.3%	13.7%
NORTH CAROLINA	3-May	30-Jun	30.3%	69.7%	65.2%	34.8%
NORTH DAKOTA	17-May	30-Jun	62.2%	37.8%	79.4%	20.6%
OHIO	10-May	30-Jun	53.3%	46.7%	80.2%	19.8%
OKLAHOMA	24-May	30-Jun	5.1%	94.9%	18.7%	81.3%
PENNSYLVANIA	24-May	30-Jun	53.8%	46.2%	79.7%	20.3%
SOUTH CAROLINA	17-May	30-Jun	8.8%	91.2%	45.5%	54.5%
SOUTH DAKOTA	17-May	30-Jun	46.7%	53.3%	66.0%	34.0%
TENNESSEE	10-May	30-Jun	25.8%	74.2%	64.2%	35.8%
TEXAS	17-May	30-Jun	3.2%	96.8%	12.3%	87.7%
VIRGINIA	10-May	30-Jun	39.9%	60.1%	69.4%	30.6%
WEST VIRGINIA	17-May	30-Jun	49.0%	51.0%	77.1%	22.9%
WISCONSIN	17-May	30-Jun	58.3%	41.7%	81.1%	18.9%

*No Delaware state crop scenario, Maryland likely representative.

Table I.4. Proportion of Days Where Cotton Dicamba Application Could Occur Below and Above Select Temperature Levels

State	Date Window		75 Degree		80 Degree	
	Start	End	% of days <75F	% of days >=75F	% of days <80F	% of days >=80F
ALABAMA	21-Apr	30-Jul	12.2%	87.8%	38.5%	61.5%
ARIZONA	10-Mar	30-Jul	20.3%	79.7%	29.9%	70.1%
ARKANSAS	21-Apr	30-Jul	13.7%	86.3%	36.1%	63.9%
FLORIDA	5-May	30-Jul	0.3%	99.7%	7.5%	92.5%
GEORGIA	21-Apr	30-Jul	13.4%	86.6%	44.2%	55.8%
KANSAS	5-May	30-Jul	16.9%	83.1%	31.0%	69.0%
LOUISIANA	21-Apr	30-Jul	12.7%	87.3%	36.1%	63.9%
MISSISSIPPI	21-Apr	30-Jul	8.9%	91.1%	29.9%	70.1%
MISSOURI	21-Apr	30-Jul	31.1%	68.9%	55.6%	44.4%
NEW MEXICO	7-Apr	30-Jul	19.4%	80.6%	29.7%	70.3%
NORTH CAROLINA	5-May	30-Jul	19.9%	80.1%	54.6%	45.4%
OKLAHOMA	21-Apr	30-Jul	10.1%	89.9%	23.0%	77.0%
SOUTH CAROLINA	28-Apr	30-Jul	12.2%	87.8%	43.2%	56.8%
TENNESSEE	28-Apr	30-Jul	24.4%	75.6%	58.1%	41.9%
TEXAS*	24-Mar	30-Jul	9.0%	91.0%	20.3%	79.7%
VIRGINIA	28-Apr	30-Jul	35.8%	64.2%	65.8%	34.2%

7. Conclusions

The overall conclusions reached from the analysis of how cut-off dates on the labels address dicamba volatility include the following

1. Temperature reductions have been demonstrated to reduce the volatility of dicamba
2. Volatility reductions with ambient temperature changes can be related to changes in field-level volatile flux rate of dicamba.
3. Changes in ambient temperature and field flux rate can be used to model the relative changes in distances where dicamba air concentrations associated observed plant effects are reached off field
4. A calculated change in field study temperature conditions at time of application down to a temperature of 80°F results in significant reduction in emissions such that the distances to plant effect associated air concentrations re brought in closure to the field, thereby mitigating some concern for near-field non-target plant effects. At 75°F these distances are brought to the very edge of the field, suggesting that concerns for wide-area exposure are greatly reduced.
5. Cut-off dates (June 30th for soybean and July 30th for cotton) when evaluated for the temperatures of 80 and 75°F, show interstate variability in their potential for limiting the potential for random application of dicamba to the crops on days that would exceed near-field

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or wide area concern temperature thresholds. In all states the range based on 80^0 F was between ~12-89% for soybean and 8-66% for cotton, leading to the conclusion that cut-off dates provide a margin of extra safety when considering their impact on avoiding application conditions favorable to off field dicamba volatile movement.

Appendix J Calculating the Cumulative Probability of Protection of Combined Volatility Control Measures for Endangered Species Protection

1. Description of the Volatility Control Measure Package

The labels contain three requirements for applicators to address volatility:

- All approved tank mixes of the dicamba products must include an approved volatility reducing agent the tank
- Application of the dicamba products are prohibited after the cut-off dates on June 30th or R1 stage on soybeans and July 30th on cotton.
- An in-field 57-foot omni-directional volatile emissions setback in select areas where necessary to protect listed species

Each of these volatility control measures address volatile emissions in different ways. The omnidirectional in-field setback is designed to place the source of dicamba volatility at sufficient distance from the field edge to prevent dicamba exposures from reaching levels that would surpass conservative effect thresholds in plants (10% VSI or 5% height reduction) off the treated field (see **Appendix F** for a discussion of the distances to which effects are predicted in the absence of the set back). The tank mixing of volatility reducing agents is designed to maintain solution pH at high enough levels to prevent the protonation of the dicamba to its most volatile acid form (see **Appendix H**). Application cut-off dates address dicamba volatility by reducing the potential for applications to occur on days where the temperature increases the volatility of dicamba (see **Appendix I**).

2. Establishment of a Conservative and Reasonable Expectation of Certainty for Effects Determinations

EPA determined that there are no discernable effects from dicamba to the most sensitive taxa, federally-listed threatened and endangered non-monocotyledon plant species beyond the action area. EPA made its effects determination based on a conservative and reasonable expectation of 95% certainty. This level of certainty is consistent with the Agency's use of reasonable upper bound exposure levels for aquatic organisms (plant and animal), and terrestrial animal screening risk assessments used to establish No Effect findings (USEPA 2004).

3. Assessment of Probabilities for Individual Volatility Control Measures

EPA has assessed the probability of each control method's succeeding or failing in preventing volatility-related adverse effects:

- The in-field omnidirectional 57-foot setback alone has been shown to be consistent with preventing dicamba exposures from reaching plant effects thresholds at the edge of field with an expectation of 78% success (failure of 22%).
- Taking into account the total number of volatile exposure transects for the available field studies using a tank mix VRA (pH-buffering agent) additive alone (**Appendix F**), the probability that the

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VRAs will prevent dicamba air concentrations associated with observations of 10% VSI or 5% height reduction (the EAAC) is 89% (failure of 11%).

- The evaluation of cut-off dates alone (**Appendix I**) established that applications of dicamba on days where the temperature is favorable for volatility emissions to produce plant effects off the field can be reduced in probability through the use of application cut-off dates. The proportion of days with volatility-favorable temperatures that are avoided with cut-off dates is state and crop dependent and ranges from a certainty of 3.2% to 72% for soybean states (28% to 97% failure) and 0.3% to 36% for cotton states (99.7 to 64% failure).

4. Cumulative Probability of Success/Failure

As can be seen above, none of the control measures alone achieve the Agency's requirement of protection with 95% certainty. However, these labelled volatility control measures work in concert, with VRAs and cut-off dates applied in all soybean and cotton growing counties in the 34 states listed on the labels, and the additional in-field 57-foot omnidirectional vapor emissions setback required in select counties where additional protection is required for the protection of federally listed species. When all three volatility control measures are in place it follows that the failure of the volatility control measure package does not truly occur for a dicamba application site unless all the methods fail. Therefore, the probability of failure of all three control measures simultaneously needs to be accounted for and compared to the limits of failure (5%) demanded by a standard of a 95% certainty of no discernable effect.

EPA used a cumulative probability calculation to estimate the probability that all three control measures will fail:

P_f control measure package = (P_f control measure 1) * (P_f control measure 2) * (P_f control measure 3)

EPA assigned to aforementioned failure rates to each of the control measures: 0.22 for omnidirectional set-back, 0.11 for the VRA, and 0.28 to 0.97 (soybean cut-off) or 0.64 to 0.997 (cotton cutoff). The resultant cumulative probabilities of failure and the resulting probability of success are presented in **Table J.1**.

Table J.1. Probability of Success or Failure for each label control measure.

Control Measure	Soybean		Cotton	
	Probability failure	Probability success	Probability failure	Probability success
57-foot set-back	0.22	0.78	0.22	0.78
VRA	0.11	0.89	0.11	0.89
Cut-off Date	0.28 – 0.97	0.03 – 0.72	0.64 -0.997	0.003 – 0.36
Cumulative	0.01-0.02	0.98 – 0.99	0.02	0.98

5. Conclusions

The requirement of all three volatility control measures yields a system failure rate of 2% or less. This leads to a success rate for the system of 98% or greater. A 98% success rate for the system of volatile controls is higher than the 95% certainty EPA determined was necessary for protection of federally listed

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species. The cumulative probability method employed assumes that the success/failure of individual control measures are independent of each other, such that the failure of one does not affect the success/failure of another. EPA concludes that this conservative approach limits possible confounding effects of interdependencies among the control measures.

Appendix K. American Burying Beetle Feeding and Depuration Model Example Input and Output

Model run for 120 hours

Hourly Feeding and Depuration Model 48g Mammal Prey of ABB

Tipping bucket assumes :	uniform prey animal feeding on maximum plant residue 10 consecutive hours/day (very conservative bias)
	prey animal pesticide loss is uniform for every hour and constant over 24 hrs (uncertain bias)
	dissipation from prey animal dietary source is trivial (conservative bias)

color denotes user entry cell		
		from MRID 51136001---Absorption Distribution Depletion and Excretion in Rats
Prey animal pesticide half -life (hours)	4	
k	0.173285	
Fraction retained at 1 hour	0.840897925	
Prey animal body weight (g)	48	
Prey animal feeding rate as 48g mammal (fw-g/day)	28	TREX estimate for 48 g mammal as fresh weight plant material
Prey animal daily feeding period (hr)	10	Assumes 10 consecutive hours per day
Prey animal feeding rate as 48g mammal (fw-g/hr)	2.8	Asumes even apportionment over feeding period
Concentration in prey animal's food item (fw mg/kg)	250	fresh weight in short grass, provided by Michael Wagman
Prey animal fraction absorbed of ingested dose	0.9	from MRID 51136001---Absorption Distribution Depletion and Excretion in Rats

Hour (note items in red are non-feeding)	mammal concentration (mg/g)	mammall concentration (mg/kg)	maximum mammal concentration (mg/kg)
1	0.013125	13.125	68.99
2	0.024161785	24.16178526	
3	0.033442595	33.44259509	
4	0.041246809	41.24680881	
5	0.047809356	47.80935593	
6	0.053327788	53.32778819	
7	0.057968226	57.96822642	
8	0.061870361	61.8703613	
9	0.065151658	65.15165842	
10	0.067910894	67.91089436	
11	0.05710613	57.10613014	
12	0.048020426	48.02042633	
13	0.040380277	40.38027685	
14	0.033955691	33.955691	
15	0.02855327	28.5532701	
16	0.024010386	24.01038557	
17	0.020190283	20.1902834	
18	0.016977967	16.97796741	
19	0.014276738	14.27673756	
20	0.012005279	12.00527899	
21	0.010095214	10.09521419	
22	0.008489045	8.489044662	
23	0.00713842	7.138420039	
24	0.006002683	6.002682597	

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Model run for 120 hours

Hourly Feeding and Depuration Model 48g Bird Prey of ABB

Tipping bucket assumes :	uniform prey animal feeding on maximum plant residue 10 consecutive hours/day (very conservative bias)
	prey animal pesticide loss is uniform for every hour and constant over 24 hrs (uncertain bias)
	dissipation from prey animal dietary source is trivial (conservative bias)

color denotes user entry cell		
Prey animal pesticide half -life (hours)	5	from MRID 00148127-Hen Metabolism
k	0.138628	
Fraction retained at 1 hour	0.870551814	
Prey animal body weight (g)	48	
Prey animal feeding rate as 48g bird (fw-g/day)	40	TREX estimate for 48 g bird as fresh weight plant material
Prey animal daily feeding period (hr)	10	Assumes 10 consecutive hours per day
Prey animal feeding rate as 48g bird (fw-g/hr)	4	Asumes even apportionment over feeding period
Concentration in prey animal's food item (mg/kg)	250	fresh weight in short grass, provided by Michael Wagman
Prey animal fraction absorbed of ingested dose	0.9	conservative estimate from MRID 00148127-Hen Metabolism

Hour (note items in red are non-feeding)	bird concentration (mg/g)	bird concentration (mg/kg)	maximum bird concentration (mg/kg)
1	0.01875	18.75	112.6786159
2	0.035072847	35.0728465	
3	0.04928273	49.28273013	
4	0.06165317	61.65317009	
5	0.072422279	72.42227903	
6	0.081797346	81.79734635	
7	0.089958828	89.9588282	
8	0.097063821	97.06382103	
9	0.103249085	103.2490854	
10	0.108633679	108.6336786	
11	0.094571246	94.57124588	
12	0.08232917	82.3291696	
13	0.071671808	71.6718079	
14	0.062394022	62.39402235	
15	0.054317229	54.31722931	
16	0.047285962	47.28596248	
17	0.04116488	41.16488039	
18	0.035836161	35.83616127	
19	0.031197235	31.19723519	
20	0.02715881	27.15880967	
21	0.023643151	23.64315101	
22	0.020582588	20.58258799	
23	0.017918209	17.9182093	
24	0.01559873	15.5987296	

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Appendix L. U.S. Fish and Wildlife Service Concurrence Memo for Eskimo Curlew Effects Determination

From: Ott, Kaithryn <Kaithryn_Ott@fws.gov>
Sent: Thursday, October 22, 2020 9:02 PM
To: Odenkirchen, Edward <Odenkirchen.Edward@epa.gov>
Subject: Re: [EXTERNAL] FW: Eskimo Curlew Updates to Effects determiantions for Dicamba Use on Cotton and Soybeans

Good afternoon Mr. Odenkirchen,

Thank you for inquiring about potential effects on Eskimo curlew from the proposed herbicide use pursuant to section 7 of the Endangered Species Act of 1973, as amended. I'm afraid the species is still presumed extinct, although we continue to hold out hope. Therefore, we agree that potential consequences for Eskimo curlew would be discountable, and concur that the proposed action is not likely to adversely affect Eskimo curlews. Please let me know if you have any other questions.

Kind regards,

Kaiti

From: Odenkirchen, Edward <Odenkirchen.Edward@epa.gov>
Sent: Thursday, October 22, 2020 1:35 PM
To: kaithryn_ott@fws.gov
Cc: Swem, Ted <ted_swem@fws.gov>
Subject: FW: Eskimo Curlew Updates to Effects determiantions for Dicamba USe on Cotton adn Soybeans

Ms. Ott,
Hello, my name is Ed Odenkirchen and I am a Senior Science advisor with USEPA Office of Pesticide programs.

I understand from a conversation with Ted Swem today that he has forwarded to you our request for a concurrence memo on an Eskimo curlew Effects Determination (May Affect but Not Likely to Adversely Affect) for a federal action involving dicamba herbicide use. Our action area overlaps with the species in Texas, Nebraska and Oklahoma. I understand Ted has given you the status of our previous consultations on essentially the same action, only now with more comprehensive risk mitigation measures in place. I am attaching the older consultation results below.

Ted informs me that you all are quite busy and reminded me of the 60-day turn around on informal consultations. We are trying to meet an ambitious schedule for finalizing this federal action decision and it would be most helpful if you could provide me with a date when you might be able to draft a response to our request.

Thanks very much

Edward Odenkirchen
Senior Science Advisor
Environmental Fate and Effects Division
Office of Pesticide Programs
United States Environmental Protection Agency

From: Swem, Ted [mailto:ted_swem@fws.gov]
Sent: Monday, May 11, 2015 5:40 PM
To: Wagman, Michael
Subject: Re: Eskimo Curlew (Dicamba ESA assessment)

Dear Mr. Wagman

Regrettably, we do concur with your determination. Although we prefer to hold out hope and have not removed the Eskimo Curlew from the list of Threatened and Endangered Species, we consider it to be "presumed extinct." We believe therefore that there are none left to encounter pesticides applied anywhere, and thus agree that the effects of the proposed action are discountable.

Thank you for checking in, though.

Ted Swem

On Mon, May 11, 2015 at 1:33 PM, Wagman, Michael <Wagman.Michael@epa.gov> wrote:
Ted Swem, Chief,
Endangered Species Branch,
Fairbanks Fish and Wildlife Field Office,
US Fish and Wildlife Service (907) 456-0441

Dear Mr. Swem

The USEPA Office of Pesticide Programs is in the process of making an effects determination for the registration of the herbicide dicamba diglycolamine (DGA) salt on cotton and soybean fields in Texas, Nebraska and Oklahoma. Use of the pesticide will be limited to ground spray application using a formulation and specific spray equipment in combination to spray drift setbacks that result in pesticide application areas of concern limited to only the actual on-field treatment site (the targeted cotton or soybean field itself).

Our review of available species location information suggests a potential for a migrant Eskimo curlew (*Numenius borealis*) passing through Texas, Nebraska and Oklahoma to encounter a treated field with dicamba DGA residues. Our analysis indicates that if such an encounter occurred, the residue levels that would trigger a concern for adverse effects to the bird. However, in reviewing the available information on the status of the Eskimo curlew[1], we have determined that individuals of the species are extremely rare. This rarity of individuals indicates to us that the chance of an individual curlew to encounter a dicamba DGA treated cotton or soybean field would be extremely unlikely to occur. Therefore any effects of dicamba DGA salt to an Eskimo curlew would be extremely unlikely to occur.
An effect that is extremely unlikely to occur would be considered discountable in regards to an effects determination and would be consistent with a determination of Not Likely to Adversely Affect. We

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therefore have determined that the proposed use of dicamba DGA salt on cotton and soybeans in Texas, Nebraska and Oklahoma will Not Likely to Adversely Affect individual Eskimo curlews.

Does the United States Fish and Wildlife Service concur with our effects determination?

Sincerely,
Michael Wagman
Biologist, Environmental Risk Branch VI
Environmental Fate and Effects Division
Office of Pesticide Programs
United States Environmental protection Agency
703-347-0198

[1] Eskimo Curlew (*Numenius borealis*) 5-Year Review: Summary and Evaluation, August 31, 2011, U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks Alaska

Appendix M. FIFRA Risk Assessment Model Input/Output Examples

Section M.1. T-REX Inputs and Outputs

Upper Bound Kenaga Residues For RQ Calculation

Chemical Name:	Dicamba
Use	DT-crops
Formulation	DT-crop products
Application Rate	0.5 lbs a.i./acre
Half-life	8.4 days
Application Interval	7 days
Maximum # Apps./Year	4
Length of Simulation	1 year
Variable application rates?	no

Endpoints			
	Bobwhite quail	LD50 (mg/kg-bw)	188.00
	Bobwhite quail	LC50 (mg/kg-diet)	>10,000
Avian	Bobwhite quail	NOAEL(mg/kg-bw)	N/A
	Bobwhite quail	NOAEC (mg/kg-diet)	695.00

Mammals		LD50 (mg/kg-bw)	2740.00
		LC50 (mg/kg-diet)	0.00
		NOAEL (mg/kg-bw)	136.00
		NOAEC (mg/kg-diet)	2720.00

Dietary-based EECs (ppm)	Kenaga Values
Short Grass	246.36
Tall Grass	112.91
Broadleaf plants	138.58
Fruits/pods/seeds	15.40
Arthropods	96.49

Avian Results

Avian Class	Body Weight (g)	Ingestion (Fdry) (g bw/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
Small	20	5	23	114	2.28E-02
Mid	100	13	65	65	6.49E-02
Large	1000	58	291	29	2.91E-01
Granivores	20	5	5	25	5.06E-03
	100	13	14	14	1.44E-02
	1000	58	65	6	6.46E-02

Avian Body Weight (g)	Adjusted LD50 (mg/kg-bw)
20	135.44
100	172.42
1000	243.55

Dose-based EECs (mg/kg-bw)	Avian Classes and Body Weights (grams)		
	small 20	mid 100	large 1000
Short Grass	280.58	160.00	71.63
Tall Grass	128.60	73.33	32.83

Broadleaf plants	157.82	90.00	40.29
Fruits/pods	17.54	10.00	4.48
Arthropods	109.89	62.67	28.06
Seeds	3.90	2.22	0.99

Dose-based RQs (Dose-based EEC/adjusted LD50)	Avian Acute RQs Size Class (grams)		
	20	100	1000
Short Grass	2.07	0.93	0.29
Tall Grass	0.95	0.43	0.13
Broadleaf plants	1.17	0.52	0.17
Fruits/pods	0.13	0.06	0.02
Arthropods	0.81	0.36	0.12
Seeds	0.03	0.01	0.00

Dietary-based RQs (Dietary-based EEC/LC50 or NOAEC)	RQs	
	Acute	Chronic
Short Grass	N/A	0.35
Tall Grass	N/A	0.16
Broadleaf plants	N/A	0.20
Fruits/pods/seeds	N/A	0.02
Arthropods	N/A	0.14

Mammalian Results

Mammalian Class	Body Weight	Ingestion (Fdry) (g bwt/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
	15	3	14	95	1.43E-02
Herbivores/	35	5	23	66	2.31E-02

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insectivores	1000	31	153	15	1.53E-01
Grainvores	15	3	3	21	3.18E-03
	35	5	5	15	5.13E-03
	1000	31	34	3	3.40E-02

Mammalian Class	Body Weight	Adjusted LD50	Adjusted NOAEL
Herbivores/ insectivores	15	6022.06	298.90
	35	4872.49	241.85
	1000	2107.50	104.61
Granivores	15	6022.06	298.90
	35	4872.49	241.85
	1000	2107.50	104.61

Dose-Based EECs (mg/kg-bw)	Mammalian Classes and Body weight (grams)		
	15	35	1000
Short Grass	234.88	162.34	37.64
Tall Grass	107.66	74.40	17.25
Broadleaf plants	132.12	91.31	21.17
Fruits/pods	14.68	10.15	2.35
Arthropods	92.00	63.58	14.74
Seeds	3.26	2.25	0.52

Dose-based RQs (Dose-based EEC/LD50 or NOAEL)	Small mammal 15 grams		Medium mammal 35 grams		Large mammal 1000 grams	
	Acute	Chronic	Acute	Chronic	Acute	Chronic
Short Grass	0.04	0.79	0.03	0.67	0.02	0.36
Tall Grass	0.02	0.36	0.02	0.31	0.01	0.16
Broadleaf plants	0.02	0.44	0.02	0.38	0.01	0.20
Fruits/pods	0.00	0.05	0.00	0.04	0.00	0.02
Arthropods	0.02	0.31	0.01	0.26	0.01	0.14
Seeds	0.00	0.01	0.00	0.01	0.00	0.00

Dietary-based RQs (Dietary-based EEC/LC50 or NOAEC)	Mammal RQs	
	Acute	Chronic
Short Grass	N/A	0.09
Tall Grass	N/A	0.04
Broadleaf plants	N/A	0.05
Fruits/pods/seeds	N/A	0.01
Arthropods	N/A	0.04

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Upper Bound Kenaga Residues For 2 Pre-emergent Applications only (used for Attwater Prairie Chicken Species Specific Effects Determination in Section 2)

Chemical Name:	Dicamba	
Use	DT-crops	
Formulation	DT-crop products	
Application Rate	0.5	lbs a.i./acre
Half-life	8.4	days
Application Interval	7	days
Maximum # Apps./Year	2	
Length of Simulation	1	year
Variable application rates?	no	

Dietary-based EECs (ppm)	Kenaga Values
Short Grass	187.35
Tall Grass	85.87
Broadleaf plants	105.38
Fruits/pods/seeds	11.71
Arthropods	73.38

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Section M.2. Bee-Rex Input and Outputs

Table M.1. User inputs (related to exposure)

Description	Value
Application rate	0.5
Units of app rate	lb a.i./A
Application method	foliar spray
Are empirical residue data available?	no

Table M.2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	91
Adult oral LD50	
Adult oral NOAEL	19
Larval LD50	
Larval NOAEL	5.1

Table M.3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	55	0.055
soil application	NA	NA
seed treatment	NA	NA
tree trunk	NA	NA

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Table 4. Daily consumption of food, pesticide dose and resulting dietary RQs for all bees

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ	Chronic RQ
Larval	Worker	1	1.9	0	0	0.001045	#DIV/0!	0.000205
		2	9.4	0	0	0.00517	#DIV/0!	0.001014
		3	19	0	0	0.01045	#DIV/0!	0.002049
		4	0	60	1.8	3.399	#DIV/0!	0.666471
		5	0	120	3.6	6.798	#DIV/0!	1.332941
	Drone	6+	0	130	3.6	7.348	#DIV/0!	1.440784
	Queen	1	1.9	0	0	0.001045	#DIV/0!	0.000205
		2	9.4	0	0	0.00517	#DIV/0!	0.001014
		3	23	0	0	0.01265	#DIV/0!	0.00248
		4+	141	0	0	0.07755	#DIV/0!	0.015206
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	3.66575	#DIV/0!	0.192934
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	8.228	#DIV/0!	0.433053
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	3.3935	#DIV/0!	0.178605
	Worker (foraging for pollen)	>18	0	43.5	0.041	2.394755	#DIV/0!	0.12604
	Worker (foraging for nectar)	>18	0	292	0.041	16.062255	#DIV/0!	0.845382
	Worker (maintenance of hive in winter)	0-90	0	29	2	1.705	#DIV/0!	0.089737
	Drone	>10	0	235	0.0002	12.925011	#DIV/0!	0.680264
	Queen (laying 1500 eggs/day)	Entire lifestage	525	0	0	0.28875	#DIV/0!	0.015197

Table M.5. Results (highest RQs)

Exposure	Adults	Larvae
Acute contact	0.014835	NA
Acute dietary	NA	NA
Chronic dietary	0.85	1.33

Section M.3. STIR Inputs and Outputs

Welcome to the EFED Screening Tool for Inhalation Risk

This tool is designed to provide the risk assessor with a rapid method for determining the potential significance of the inhalation exposure route to birds and mammals in a risk assessment.

Input

NOTE: When entering values, press in order to update linked cells.

Application and Chemical Information

Enter Chemical Name	Dicamba
Enter Chemical Use	Cotton/Soy
Is the Application a Spray? (enter y or n)	y
If Spray What Type (enter ground or air)	ground
Enter Chemical Molecular Weight (g/mole)	221
Enter Chemical Vapor Pressure (mmHg)	3.41E-05
Enter Application Rate (lb a.i./acre)	0.5

Toxicity Properties

Bird

Enter Lowest Bird Oral LD_{50} (mg/kg bw)	188
Enter Mineau Scaling Factor	1.15
Enter Tested Bird Weight (kg)	0.178

Mammal

Enter Lowest Rat Oral LD_{50} (mg/kg bw)	2740
Enter Lowest Rat Inhalation LC_{50} (mg/L)	5.3
Duration of Rat Inhalation Study (hrs)	4
Enter Rat Weight (kg)	0.35

Output

Results Avian (0.020 kg)

Maximum Vapor Concentration in Air at Saturation (mg/m^3)	4.06E-01	
Maximum 1-hour Vapor Inhalation Dose (mg/kg)	5.10E-02	
Adjusted Inhalation LD_{50}	2.03E+00	
Ratio of Vapor Dose to Adjusted Inhalation LD_{50}	2.51E-02	Exposure not Likely Significant
Maximum Post-treatment Spray Inhalation Dose (mg/kg)	5.28E-02	
Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}	2.61E-02	Exposure not Likely Significant

Results Mammalian (0.015 kg)

Maximum Vapor Concentration in Air at Saturation (mg/m^3)	4.06E-01	
Maximum 1-hour Vapor Inhalation Dose (mg/kg)	6.41E-02	
Adjusted Inhalation LD_{50}	3.16E+02	
Ratio of Vapor Dose to Adjusted Inhalation LD_{50}	2.03E-04	Exposure not Likely Significant
Maximum Post-treatment Spray Inhalation Dose (mg/kg)	6.64E-02	
Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}	2.10E-04	Exposure not Likely Significant

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Appendix N. Dicamba Crop Field Trial Residue Data Which Include the Determination of the DCSA Metabolite.

Table N.1. Summary of Residues from Conventional Asparagus Crop Field Trials with DCSA as a Dicamba Residue of Concern.[1]											
Formulation[2]	Total Application Rate (lb ae/A)	PHI (days)	N[3]	Residue of Concern	Combined Residues (ppm)						
					Min.	Max.	LAFT[5]	HAFT[5]	Median[5]	Mean[5]	SD[5]
4 lb ae/gal DGA SL, 4 lb ae/gal DGA SL, and 2 lb ae/gal Na SL	Single post-emergence broadcast application of 0.5 lb ae/A	1	24	Parent	0.266	3.274	0.304	3.144	0.604	0.967	0.852
				DCSA[4]	<0.01	0.071	<0.01	<0.040	0.011	0.014	0.0069
				Total	0.271	3.192	0.314	3.166	0.622	0.981	0.854

[1] Asparagus data are taken directly from MRID Nos. 43245206 and 43425803 (D204488, D204809, and D209229, L. Cheng, 07/14/1997) used for tolerance re-assessment in the 2005 RED.
[2] Test applications included the dimethylamine (DMA), diglycolamine (DGA), and sodium (Na+) salt formulations.
[3] number of samples.
[4] DCSA is the 3,6-dichloro-2-hydroxybenzoic acid metabolite.
[5] Values based on per-trial averages. LAFT = lowest average field trial, HAFT = highest average field trial, SD = standard deviation. For computation of the LAFT, HAFT, median, mean, and standard deviation, values < LOQ are assumed to be at the LOQ (0.01 ppm).

Table N.2. Summary of Residues from Conventional Soybean Crop Field Trials (Seed) with DCSA as a Dicamba Residue of Concern.[1,2]											
Formulation[3]	Total Application Rate (lb ae/A)	PHI (days)	N[4]	Residue of Concern	Combined Residues (ppm)						
					Min.	Max.	LAFT[6]	HAFT[6]	Median[6]	Mean[6]	SD[6]
4 lb ae/gal DMA SL	Single 0.5 lb ae pre-plant treatment followed by a single post-emergence application of 2.0 lb ae/A	7	24	Parent	0.027	8.10	0.038	7.40	0.72	1.022	1.703
				DCSA[5]	<0.01	0.130	<0.01	<0.048	.014	0.02	0.015
				5-OH dicamba	<0.01	0.360	<0.01	0.26	0.01	0.043	0.071
				Total	0.047	8.14	0.084	7.44	0.768	1.085	1.713

[1] Soybean grain data are for the 1X rate which used a 0.5 lb ae/A treatment made at 14-days pre-planting followed by a 2.0 lb ae/A treatment made at 7-days prior to harvest taken directly from MRID Nos. 43814101 (D223283, S. Knizner, 07/29/1996) and 44089307 (D228703, S. Chun, 07/16/1998) used for tolerance reassessment in the 2005 RED.

[2] The registrant was not supporting tolerances for soybean forage and hay at this time in lieu of a feeding restriction placed on the label. However, data were included for these commodities in the study submissions acquired using a single 0.5 lb ae/A treatment made at 14-days pre-planting (0.25x the maximum rate). Total residues of dicamba (parent, DCSA, and 5-OH dicamba) were <0.03 - <0.097 ppm in soybean forage and <0.03 - <0.04 ppm in soybean hay.

[3] Test applications included the dimethylamine (DMA) salt formulation.

[4] number of samples.

[5] DCSA is the 3,6-dichloro-5-hydroxybenzoic acid metabolite.

[6] Values based on per-trial averages. LAFT = lowest average field trial, HAFT = highest average field trial, SD = standard deviation. For computation of the LAFT, HAFT, median, mean, and standard deviation, values < LOQ are assumed to be at the LOQ (0.01 ppm).

Table N.3. Summary of Residues from Dicamba-Tolerant Cotton Crop Field Trials with DCSA as a Dicamba Residue of Concern.

Commodity	Analyte	Total App. Rate lb ae/A (kg ae/ha)	PHI (days)	Residue Levels (ppm)[1]							
				n	Sample Min.	Sample Max.	LAFT[2]	HAFT[2]	Median	Mean	Std. Dev.
TRT 2 (Applications at Preemergence, 6-leaf stage, and first white flower + 15 days; EP: Clarity)											
Undelinted Cotton seed	Dicamba	2.0 (2.2)	49-105	13	<0.02	<0.02	<0.02	<0.02	0.02	0.02	N/A
	5-OH Dicamba			13	<0.02	<0.02	<0.02	<0.02	0.02	0.02	N/A
	DCSA			13	<0.02	0.23	<0.02	0.23	0.02	0.04	0.06
	Combined Residues			**13**	**<0.06**	**<0.28**	**<0.06**	**<0.28**	**0.06**	**0.09**	**0.06**
Gin byproducts	Dicamba	2.0 (2.2)	82-84	3	<0.04	<0.04	<0.04	<0.04	0.04	0.04	N/A
	5-OH Dicamba			3	<0.04	<0.04	<0.04	<0.04	0.04	0.04	N/A
	DCSA			3	0.39	1.73	0.43	1.58	0.67	0.89	0.61
	Combined Residues			**3**	**<0.47**	**<1.82**	**<0.53**	**<1.66**	**0.75**	**0.97**	**0.61**
TRT 3 (Applications at Preemergence, first open boll stage, and 7 days prior to harvest; EP: Clarity)											
Undelinted Cotton seed	Dicamba	2.0 (2.2)	6-8	13	0.06	1.97	0.06	1.38	0.65	0.64	0.43
	5-OH Dicamba			13	<0.02	0.02	<0.02	<0.02	0.02	0.02	N/A
	DCSA			13	<0.02	0.25	<0.02	0.16	0.03	0.05	0.05
	Combined Residues			**13**	**<0.12**	**<2.24**	**<0.10**	**<1.56**	**0.71**	**0.71**	**0.48**
TRT 4 (Applications at 6-leaf, first white flower + 15 days, first open boll, and 7 days prior to harvest; EP: Clarity)											
Undelinted Cotton seed	Dicamba	2.0-2.1 (2.2-2.4)	6-8	13	0.09	1.54	0.12	1.42	0.47	0.61	0.41
	5-OH Dicamba			13	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	N/A
	DCSA			13	0.02	0.27	0.02	0.27	0.06	0.08	0.07
	Combined Residues			**13**	**<0.13**	**<1.83**	**<0.16**	**<1.72**	**0.56**	**0.71**	**0.48**
TRT 4 (Applications at 6-leaf, first white flower + 15 days, first open boll, and 7 days prior to harvest; EP: Clarity)											
Gin byproducts	Dicamba	2.0 (2.2)	6-7	3	3.09	23.6	3.13	23.0	14.9	13.7	10.0
	5-OH Dicamba			3	<0.04	0.04	<0.04	<0.04	0.04	0.04	N/A
	DCSA			3	1.70	6.29	1.78	6.17	4.50	4.15	2.22
	Combined Residues			**3**	**<4.83**	**29.9**	**<5.06**	**<29.6**	**19.7**	**18.1**	**12.2**
TRT 5 (Applications at 6-leaf, first white flower + 15 days, first open boll, and 7 days prior to harvest; EP: MON 11968)											
Undelinted Cotton seed	Dicamba	2.0 (2.2)	7-8	4	0.17	0.72	0.20	0.62	0.41	0.41	0.23
	5-OH Dicamba			4	<0.02	<0.02	<0.02	<0.02	0.02	0.02	N/A
	DCSA			4	0.02	0.17	0.02	0.12	0.04	0.06	0.04
	Combined Residues			**4**	**<0.21**	**<0.91**	**<0.24**	**<0.76**	**0.47**	**0.49**	**0.27**

[1] Except for sample min/max, values reflect per trial averages; n = no. of field trials. For calculation of median, mean, and standard deviation, the LOQ (0.02 ppm each analyte in undelinted cotton seed and 0.04 ppm for each analyte in cotton gin byproducts) was used for any results reported as <LOQ in Table C.3. Combined residues of dicamba, 5-OH dicamba, DCGA, and DCSA are expressed in parent equivalents. Individual analyte results are reported as per se. N/A = Not applicable.

[2] LAFT = lowest-average-field-trial; HAFT = highest-average-field-trial.

Table N.4. Summary of Residues from Dicamba-Tolerant Soybean Crop Field Trials with DCSA as a Dicamba Residue of Concern.

Commodity	Total Applic. Rate lb a.e./A (kg a.e./ha)	PHI (days)	Residue Levels[a, b] (ppm)						
			N	Min.	Max.	HAFT	Median (STMdR)	Mean (STMR)	Std. Dev.
DCGA[c]									
Forage	1.96-2.04 (2.19-2.28)	7-10	44	0.356	5.90	5.27	1.93	2.02	1.02
Hay		13-15	44	0.167	7.26	7.19	2.00	2.66	1.91
Seed		73-98	44	<0.011	0.135	0.131	0.017	0.032	0.029
DCSA									
Forage	1.96-2.04 (2.19-2.28)	7-10	44	**8.92**	**51.3**	50.4	15.0	17.0	8.00
Hay		13-15	44	**12.2**	**61.1**	60.7	31.9	32.2	11.2
Seed		73-98	44	0.010	0.440	0.439	0.033	0.059	0.089
Dicamba									
Forage	1.96-2.04 (2.19-2.28)	7-10	44	**<LOQ**	**2.62**	2.47	0.068	0.374	0.603
Hay		13-15	44	**<LOQ**	**1.16**	1.01	0.051	0.130	0.216
Seed		73-98	44	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
5-OH Dicamba									
Forage	1.96-2.04 (2.19-2.28)	7-10	44	<LOQ	0.009	0.009	0.005	0.006	<LOQ
Hay		13-15	44	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Seed		73-98	44	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ

[a]Concentrations of the individual analytes are reported as dicamba equivalents
[b]Values < LOQ are assumed to be at the LOQ.
[c] DCGA residues were quantitated by a non-validated method

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Appendix O. Consideration of the Option to use Hooded Sprayers and Its impact on the Action Area of the Dicamba Federal action

The product labels contain an optional approach to address off-site transport of spray drift. The labels contain the requirement for an infield downwind spray drift setback of either 240 ft or 310 feet. These two required setbacks, as summarized in Section 2, result in a spray drift-considered action area extent of just the borders of the treated soybean or cotton field when the 310 ft setback is required in a select 287 counties. In the remaining counties, where a 240 ft setback is required, the action includes the treated soybean or cotton field and an additional 70 feet outside the crop field.

Product labels allow for an optional approach in soybean fields, where the use of specific hooded sprayers can be used in conjunction with smaller infield downwind spray drift setbacks of 110 ft in the majority of counties where a 240 ft setback is otherwise required or 240 ft in any of 287 counties where a 310 ft setback is required.

The purpose of this Appendix was to determine if the option to use a smaller spray drift setback in combination with a particular hooded sprayer (RedBall 642E) would affect the above action area for this federal Action. This analysis included an evaluation of the impact of hooded sprayers on the distance to effects for non-monotonic plants which is the taxon of greatest dicamba sensitivity and the basis for the action area extent. The analysis then compared the potential off field distances in excess of treated fields where effects can reasonably be expected to occur with the hooded sprayer option to the distances which informed the action area extent.

1. Analysis of Available Distances to Effect Data for Hooded Sprayer Field Studies and Setting Setbacks with Hooded Sprayer Use

Three field trials were conducted evaluating the offsite spray drift deposition of dicamba during applications using a Redball hooded sprayer on bare soil and soybean crops (**Appendix G**). One study (MRID 51242201) was a series of 12 trials conducted on bare soil where the distance to the soybean NOAEL (2.61×10^{-4} lb a.e./A) was less than the nearest sampler distance, 4 m (13 feet). The remaining two trials (MRID 51320201) were conducted as over the top treatments to soybeans. One trial was conducted in Arizona, where 10 A plots of soybean at the V1 growth stage were treated. The distance to the NOAEL for soybeans was less than the nearest sampler distance, 9.8-11 feet, for all but one transect, where the distance was 20 ft. The second trial was conducted in Missouri on a 7 A field of soybeans at the V6-V7 stage. The distance to the NOAEC for soybeans along all transects was less than the nearest sampler distance of 3 m (9.8 ft). Plant effects data provided by the registrant for the Missouri trial indicate that there were no visual signs of injury or significant reductions of plant height for any transect with reported results. However, due to uncertainties in the control data and missing data for entire transects, as well as the lack of a formal report and metadata surrounding the potential exposure does not allow EPA to fully evaluate the effects on plant data for this trial.

2. Comparison of the Likely Action Area Extent using the Hooded Sprayer Option with The Action Area Using the 240 ft and 310 ft Infield Setbacks.

As stated earlier, the spray drift contribution to the action area forms the basis for the total aerial extend of the action area for the dicamba registrations. In counties with a 240 ft in-field spray drift setback the action area includes the treated soybean or corn field and an area extent 70 ft outside the fields. In the counties with a 310 ft setback the action area extends only to the treated field borders.

The distributional analysis from the data available for the distances from particular hooded sprayer (RedBall 642E) field trials performed with Crystal Ball (**Appendix G**) suggests that, with this limited data set, the distances to a soybean NOAEL would not extend beyond 20 ft with 95% certainty (the same certainty level used to establish the action area for listed species effects determinations). With the use of hooded sprayers alone the resulting 20 ft beyond treated field distance for effects would fall within the action area limits established for counties with a 240 ft setback (treated field plus 70 ft), but not for the counties with a 310 ft setback (treat field edge). Without further requirements this would result in residual distances beyond the existing action area for all counties.

To address the limitations in the number of field trials and to address the potential for further distances to the 10% VSI threshold relative to distances to the soybean NOAEL, the hooded sprayer option includes a requirement for in-field setbacks. The combination of the in-field setbacks with the hooded sprayer moves the sources of dicamba further away from the field edge by a factor of 5x or more and allows EPA to conclude that the off-field extent of effects used to define action area in all counties would be no larger than that established using the 240 ft and 310 ft in-field spray drift setbacks alone.